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INTERNATIONAL APPLICATION NO.
PCT/IB00/00918INTERNATIONAL FILING DATE
July 7, 2000PRIORITY DATE CLAIMED
July 9, 1999

TITLE OF INVENTION

DNA Polymorphisms in Sterol Regulator Element Binding Proteins

APPLICANT(S) FOR DO/EO/US

André R. Miserez

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☐ This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include items (5), (6), (9) and (21) indicated below.
4. ☒ The US has been elected by the expiration of 19 months from the priority date (Article 31).
5. ☒ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
 - a. ☒ is attached hereto (required only if not communicated by the International Bureau).
 - b. ☒ has been communicated by the International Bureau.
 - c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☒ An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).
 - a. ☒ is attached hereto.
 - b. ☐ has been previously submitted under 35 U.S.C. 154(d)(4).
7. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
 - a. ☐ are attached hereto (required only if not communicated by the International Bureau).
 - b. ☐ have been communicated by the International Bureau.
 - c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
 - d. ☒ have not been made and will not be made.
8. ☐ An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☒ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)). (unsigned)
10. ☐ An English language translation of the annexes of the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11 to 20 below concern document(s) or information included:

11. ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. ☒ A **FIRST** preliminary amendment.
14. ☐ A **SECOND** or **SUBSEQUENT** preliminary amendment.
15. ☐ A substitute specification.
16. ☐ A change of power of attorney and/or address letter.
17. ☐ A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821 - 1.825.
18. ☐ A second copy of the published international application under 35 U.S.C. 154(d)(4).
19. ☐ A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).
20. ☒ Other items or information: Please see attached page 3.

21. ☒ The following fees are submitted:

BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)):

Neither international preliminary examination fee (37 CFR 1.482)
nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO
and International Search Report not prepared by the EPO or JPO. \$1040.00International preliminary examination fee (37 CFR 1.482) not paid to
USPTO but International Search Report prepared by the EPO or JPO. \$890.00International preliminary examination fee (37 CFR 1.482) not paid to USPTO
but international search fee (37 CFR 1.445(a)(2)) paid to USPTO. \$740.00International preliminary examination fee (37 CFR 1.482) paid to USPTO
but all claims did not satisfy provisions of PCT Article 33(1)-(4). \$710.00International preliminary examination fee (37 CFR 1.482) paid to USPTO
and all claims satisfied provisions of PCT Article 33(1)-(4). \$100.00

ENTER APPROPRIATE BASIC FEE AMOUNT =

CALCULATIONS PTO USE ONLY

Surcharge of \$130.00 for furnishing the oath or declaration later than ☐ 20 ☐ 30
months from the earliest claimed priority date (37 CFR 1.492(e)).

\$ 890.00

\$ 0.00

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE	\$
Total claims	31 - 20 =	11	x \$18.00	\$ 198.00
Independent claims	3 - 3 =	0	x \$84.00	\$ 0.00
MULTIPLE DEPENDENT CLAIM(S) (if applicable)			+ \$280.00	\$ 0.00

TOTAL OF ABOVE CALCULATIONS = \$ 1,088.00

☐ Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above
are reduced by 1/2.

SUBTOTAL = \$ 1,088.00

Processing fee of \$130.00 for furnishing the English translation later than ☐ 20 ☐ 30
months from the earliest claimed priority date (37 CFR 1.492(f)).

\$ 0.00

TOTAL NATIONAL FEE = \$ 1,088.00

Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be
accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). \$40.00 per property +

\$

TOTAL FEES ENCLOSED = \$ 1,088.00

Amount to be
refunded:

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- a. ☒ A check in the amount of \$ 1,088.00 to cover the above fees is enclosed.
- b. ☐ Please charge my Deposit Account No. _____ in the amount of \$ _____ to cover the above fees.
A duplicate copy of this sheet is enclosed.
- c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any
overpayment to Deposit Account No. 03-3125. A duplicate copy of this sheet is enclosed.
- d. ☐ Fees are to be charged to a credit card. WARNING: Information on this form may become public. Credit card
information should not be included on this form. Provide credit card information and authorization on PTO-2038.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR
1.137 (a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

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NAME Donald S. Dowden

REGISTRATION NUMBER 20,701

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicants : André R. Miserez

Serial No. : Not Yet Known

Filing Date : Herewith

For : DNA Polymorphisms in Sterol Regulator Element Binding Proteins

International Application No. : PCT/IB00/00918

Priority Date Claimed : July 9, 1999

Group A.U. : Not Yet Known

Examiner : Not Yet Known

List of Other Items of Information

1. Express Mail Certificate of Mailing No. EL013823102US;
2. Copy of PCT Request;
3. Copy of PCT Demand;
4. Copy of PCT Notification of Transmittal of the International Preliminary Examination Report;
5. Copy of International Preliminary Examination Report;
6. Copy of PCT Written Opinion dated June 19, 2001;
7. Copy of Answer dated September 17, 2001;
8. Copy of PCT Notification of Receipt of Record Copy; and
9. Return Postcard.

02280US DNA POLYMORPHISMS IN STEROL-REGULATOR-ELEMENT BINDING
PROTEINS

Cross References to Related Applications

5

This application claims the priority of Swiss patent application 1277/99, filed July 9, 1999, the disclosure of which is incorporated herein by reference in its entirety.

10

Technical Field

The present invention relates to polymorphisms, in particular deoxyribonucleic acids (DNA or
15 DNS)-polymorphisms, in Sterol-Regulator Element-Binding Proteins, in particular protein-1 (SREBP-1) and protein-2 (SREBP-2) or the use of said polymorphisms for diagnosis, respectively, but as well for active compound screening.

20

Background Art

In the last decades, epidemiological long term studies have identified numerous factors accelerating formation of atherosclerosis and thereby promoting development of cardiac infarctions. Despite of avoiding
25 risk factors and of behavior increasing the risk of atherosclerosis, the development of pronounced atherosclerotic changes culminating in heart infarction can even be observed in young adults. In such cases, genetic factors play a decisive role. It is for example known that defects of genes playing an important role in cholesterol
30 metabolism require medication with cholesterol lowering drugs. The early detection of a genetic defect allows that counter measures can be taken in time.

Therefore, it is desirable both from a diagnostic point of view and from a therapeutical point of view to be able to recognize and to detect crucial genetic alterations (see A.R. Miserez, Die Bedeutung ge-
35

Applicant or Patentee: _____ Attorney's
 Serial or Patent No.: _____ Docket No.: _____
 Filed or Issued: _____
 For: DNA Polymorphisms in Sterol Regulator Element Binding Proteins

VERIFIED STATEMENT (DECLARATION) CLAIMING SMALL ENTITY
 STATUS (37 CFR 1.9(f) and 1.27(b)) - INDEPENDENT INVENTOR

As a below named inventor, I hereby declare that I qualify as an independent inventor as defined in 37 CFR 1.9(c) for purposes of paying reduced fees under section 41(a) and (b) of Title 35, United States Code, to the Patent and Trademark Office with regard to the invention entitled DNA Polymorphisms in Sterol Regulator Element Binding Proteins described in _____

- ☐ the specification filed herewith
☒ application serial no. _____, filed _____
☐ patent no. _____, issued _____

I have not assigned, granted, conveyed or licensed and am under no obligation under contract or law to assign, grant, convey or license, any rights in the invention to any person who could not be classified as an independent inventor under 37 CFR 1.9(c) if that person had made the invention, or to any concern which would not qualify as a small business concern under 37 CFR 1.9(d) or a nonprofit organization under 37 CFR 1.9(e).

Each person, concern or organization to which I have assigned, granted, conveyed, or licensed or am under an obligation under contract or law to assign, grant, convey, or license any rights in the invention is listed below:

- ☐ no such person, concern, or organization
☐ persons, concerns or organizations listed below*

*NOTE: Separate verified statements are required from each named person, concern or organization having rights to the invention averring to their status as small entities. (37 CFR 1.27)

FULL NAME _____
 ADDRESS _____
☐ INDIVIDUAL ☐ SMALL BUSINESS CONCERN ☐ NONPROFIT ORGANIZATION

FULL NAME _____
 ADDRESS _____
☐ INDIVIDUAL ☐ SMALL BUSINESS CONCERN ☐ NONPROFIT ORGANIZATION

FULL NAME _____
 ADDRESS _____
☐ INDIVIDUAL ☐ SMALL BUSINESS CONCERN ☐ NONPROFIT ORGANIZATION

I acknowledge the duty to file, in this application or patent, notification of any change in status resulting in loss of entitlement to small entity status prior to paying, or at the time of paying, the earliest of the issue fee or any maintenance fee due after the date on which status as a small entity is no longer appropriate. (37 CFR 1.28(b))

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application, any patent issuing thereon, or any patent to which this verified statement is directed.

André R. Miserez
 NAME OF INVENTOR _____ NAME OF INVENTOR _____
 Signature of Inventor _____ Signature of Inventor _____
 Date _____ Date _____

netischer Faktoren bei der Entstehung des Herzinfarkts, uni nova, April 1998, S. 44-52).

Cholesterol, besides being the precursor of steroid hormones and bile acids, is an essential constituent of the cell membrane decisively enhancing its permeability-barrier properties. Human cells control their intracellular cholesterol concentration tightly by regulating the receptor-mediated uptake of extracellular cholesterol-containing low density lipoproteins (LDL) and the intracellular cholesterol biosynthesis. LDL particles bind to the LDL receptor (LDLR) by their apolipoprotein (apo) B moieties. The binding and subsequent internalization of these lipoprotein-receptor complexes can be partially or completely abolished if one of the proteins involved in this process is defective or missing. Mutations of the genes encoding the apolipoprotein E (causing familial dysbetalipoproteinemia (FDL)), the apo B-100 (causing familial defective apo B (FDB)), and the LDL receptor (causing familial hypercholesterolemia (FH)) lead to an accumulation of cholesterol-containing particles in the plasma, which is associated with an increased risk of coronary artery disease. In most of the tested populations, said mutations can only explain 4.2 to 7 % of cases with hypercholesterolemia (defined as the 10% of persons of a population with LDLC concentrations above the ninetieth percentile). Thus, the casual gene defects for the majority of affected people with increased plasma LDLC are not yet identified.

The promoters of the LDLR gene and of the genes involved in the cholesterol biosynthesis including the hydroxymethylglutaryl (HMG) CoA synthase, farnesyl-pyrophosphate synthase, and squalene synthase genes, contain specific nucleotide sequences, so-called sterol regulatory elements (SREs).

It is already known that two proteins, SRE-binding protein- (SREBP-) 1 and SREBP-2, bind the SREs in the promoters of these genes and activate their tran-

scription rates. When cells are deprived of sterols, both proteins are activated by two proteolytic steps, first by a sterol-sensitive, and then by a cholesterol-independent step. These cleavage events release 68 kDa peptides from the NH₂-terminal region of the SREBP-1 and -2 precursor proteins in the cytoplasm. The NH₂-terminal, mature form of the transcription factors enters the nucleus and binds the SREs in the promoters of cholesterol-regulating genes. As a consequence, these genes are activated, thus leading to an increase in the receptor-mediated uptake of LDL as well as to an enhanced intracellular cholesterol biosynthesis.

When cholesterol accumulates in the cell, the first, cholesterol-sensitive cleavage event is inhibited, the mature forms of the SREBPs disappear and transcription rates decline, thereby preventing excessive accumulation of cholesterol in the cell. SREBP-1 and SREBP-2 regulate numerous SRE-containing genes involved in cholesterol homeostasis. In addition, SREBP-1 activates the HMG CoA reductase and the squalene synthase. SREBP-1 and SREBP-2 are members of the so-called basic helix-loop-helix leucine zipper transcription factor family. The genes encoding these factors have been cloned recently, and their genetic structures have been characterized (20,21).

Despite of the available knowledge, the percentage - as mentioned above - of identifiable risk patients for e.g. hypercholesterolemia is below 7 %.

Therefore, the present invention had the aim to improve the early diagnosis and therapy of risk patients.

Said aim is achieved by providing diagnostic methods as well as polymorphisms in the SREBP genes which are suitable for the use in said diagnostic methods, in particular polymorphisms which are found in a fraction of patients with altered lipid metabolism, in particular

cholesterol metabolism, preferably in a big fraction of such patients.

Disclosure of the Invention

5 Hence, it is a general object of the invention to provide a method for the detection of an increased or reduced disease risk and/or mortality risk and/or an increased or reduced sensitivity to therapeutic methods or side effects, respectively.

10 Further objects of the present invention are the use of polymorphisms for diagnosis, for the evaluation of disease treatments and for drug screening as well as the provision of suitable polymorphisms.

15 It was surprisingly found that polymorphisms in sterol-regulator element binding proteins (SREBP), in particular SREBP-1 and SREBP-2, are indicators for health risks or therapy risks, respectively. The method according to the invention is characterized in that after having taken a blood or tissue sample, respectively, said
20 blood or tissue sample, respectively, is examined for the presence of a polymorphism in at least one SREBP wherein the presence of a polymorphism can be determined on nucleic acid level and/or protein level. The term polymorphism as used herein describes each naturally occurring
25 sequence variation in humans, preferably a sequence variation found in a big percentage of the population.

 In a preferred method nucleic acid sequences having a characteristic polymorphism, in particular a polymorphism of SREBP-1 and/or SREBP-2, are used on a DNA
30 and/or RNA chip, so called microarray (DNA chip) technology. Other methods are e.g. PCR followed by a restriction digestion, e.g. with MspI or XmnI, respectively; single stranded conformation polymorphism (SSCP) method, denaturing gradient gel electrophoresis (DGGE) method; protein
35 truncation test (PTT); restriction fragment length polymorphism (RFLP) method; Cleavage fragment length polymorphism (CFLP) method; chemical cleavage of mis-

matches method; sequencing, minisequencing (snap shot sequencing); methods based on high pressure liquid chromatography (HPLC) (dHPLC); methods based on mass spectroscopy; dot blot methods (allele specific oligonucleo-
5 tides): allele specific PCR methods (allele specific oligonucleotides); real time quantitative PCR spectrophotometry (e.g. TaqManTM, Light CyclerTM); and luminescent non-gel based molecular interrogation.

The polymorphisms which are in the scope of
10 the present invention of special interest, in particular polymorphisms found in the SREBP-1 and SREBP-2 genes, are associated with an altered protein function. The presence of mutations in the SREBP-1 and SREBP-2 gene which are below further described leads e.g. to an improved or re-
15 duced activation of the LDL receptor resulting in an altered cholesterol level in humans.

In the scope of the present invention it was further found that corresponding polymorphisms are indicators for an increased or reduced disease risk, in particular for an increased or reduced risk, respectively,
20 to become affected of hypercholesterolemia or Alzheimer's disease. Said polymorphisms allow also an evaluation of the risk for the occurrence of problems associated with HIV therapy, in particular the therapy with protease in-
25 hibitors and allow a risk assessment for the development of any disease associated with an increased mortality risk, independently of an optionally associated cholesterol modification or Alzheimer's disease.

The invention is further described below and
30 by the figures.

Brief Description of the Drawings

Figure 1A shows a chromatogram for the identification of the exon polymorphism in SREBP-1, and the detected polymorphism, namely a mutation in the SREBP-1 gene (exon 18c) at amino acid position 1028 (G1028G)
35

which does not lead to an amino acid substitution but generates a *Xmn I* restriction site.

Figure 1B shows a chromatogram for the identification of the exon polymorphism in SREBP-2, and the
5 detected polymorphism, namely a mutation in the SREBP-2 gene (exon 10) at amino acid position 595 (A595G) which leads to an amino acid substitution (alanine to glycine) and additionally generates a *MspI* restriction site.

Figure 2A shows how homozygous and heterozy-
10 gous carriers of the corresponding mutation can be identified by large scale screening of large person groups by means of PCR amplification of the whole exon 18c (SREBP-1) and subsequent restriction enzyme digestion.

Figure 2B shows how homozygous and heterozy-
15 gous carriers of the corresponding mutation can be identified by large scale screening of large person groups by means of PCR amplification of the whole 5' end of exon 10 (SREBP-2) and subsequent restriction enzyme digestion.

Figure 3 shows for SREBP-1 and SREBP-2 the
20 comparison between carriers and non-carriers of the polymorphisms with regard to the corresponding, average total cholesterol concentration and the gene-gene interaction with apolipoprotein E-gene.

Figure 4 shows the percentage alteration of
25 the plasma cholesterol levels before and after administration of protease inhibitors depending on G1028G polymorphism.

Modes for Carrying Out the Invention

30

Polymorphisms in the SREBP genes can generally be detected as described below for the SREBP-1 and SREBP-2 genes.

The special polymorphisms can e.g. be de-
35 tected by designing oligonucleotides corresponding to the intron sequences of SREBP-1 and SREBP-2 genes which are directly adjacent to the exon/intron boundary and by

testing both genes for sequence variations using the single stranded conformation polymorphism method.

In this way the following relative often occurring polymorphisms were found. Each of said polymorphisms is compared to the normal gene wherein NS refers to the nucleic acid sequence and AS refers to the amino acid sequence:

SREBP-1 (wildtype):

10 NS G CAC CTA GGC AAA GGC TTC (Seq. Id. No. 1)
AS H L G K G F (Seq. Id. No. 2)

SREBP-1-exon 18c-polymorphism (SREBP-1-G1028G or SREBP-1c-G1028G):

15 NS G CAC CTA GGG AAA GGC TTC (Seq. Id. No. 3)
AS H L G K G F (Seq. Id. No. 4)

SREBP-2 (wildtype):

20 NS CT GCT GCC GCC AAC CTA CA (Seq. Id. No. 5)
AS A A A A N L Q (Seq. Id. No. 6)

SREBP-2-exon 10-polymorphism (SREBP-2-A595G):

25 NS CT GCT GCC GGC AAC CTA CA (Seq. Id. No. 7)
AS A A A G N L Q (Seq. Id. No. 8)

In the same manner, a further polymorphism with a relative high incidence was found which in the meantime was published in the context of a diploma thesis (see diploma thesis done at the department of research, university hospitals Basel, by Patrick Y. Müller, „Sterol regulatory element binding protein 2:....“) and which subsequently was designated SREBP-2-exon-6-polymorphism or SREBP-2-R371K.

A comparison of the wildtype sequence to said further polymorphism shows a substitution at the protein level, namely mutation of an arginine (R) to a lysine (K) at position 371 (R371K) in exon 6, namely:

SREBP-2 (wildtype):

NS	CTG	AGG	AAG
AS	L	R	K

5 **SREBP-2-exon 6-polymorphism (SREBP-2-R371K):**

NS	CTG	AAG	AAG
AS	L	K	K

As can be seen from the above sequences, each of said polymorphisms has an altered nucleic acid in the exon range wherein only two of said three polymorphisms, namely those of SREBP-2, have a mutation which is detectable at the protein level (see figure 1A, figure 1B). But all three polymorphisms generate new cleavage sites for restriction enzymes, namely in SREBP-1 a cleavage site for XmnI and in SRBEP-2 a cleavage site for MspI or DdeI, respectively.

It is obvious that said polymorphisms are as well present in the complementary strands so that any reference throughout this application to nucleotide sequences comprises the corresponding disclosure of said complementary sequences.

The finding that the polymorphism in the SREBP-1 gene does not lead to an alteration at the protein level but nevertheless can be correlated with the incidence of hypercholesterolemia strongly suggests that said polymorphism is associated with one or several mutation in the same gene or has an influence at the RNA level. Said hypothesis is in agreement with the fact that said polymorphism in the SREBP-1 gene not only is associated with the incidence of hypercholesterolemia but at the same time is associated in HIV patients with a deficiency to increase the total cholesterol concentration and triglyceride concentration after administration of protease inhibitors. Therefore, said polymorphism is a valuable tool for the risk assessment for the incidence

of undesired effects and cessation of a treatment with protease inhibitors.

Another valuable feature of the described polymorphisms, in particular of the SREBP-2-A595G-polymorphism, is its prevalence in patients with Alzheimer's disease in comparison with its presence in the population in general, namely 7 % in patients with Alzheimer's disease compared to 2.4 % in the population in general.

Furthermore, it was surprisingly found that all three polymorphisms which are further described above have a significant influence on the mortality of its carrier.

It can be summarized that SREBP-2-A595G is particularly suitable to make a statement concerning the risk for a general cholesterol increase whereas SREBP-1c-G1028G is particularly suitable as a prognostic marker for the individual reaction (risk for cholesterol increase) after administration of medicaments. For statements concerning the risk of developing Alzheimer's disease (also independent of an optionally associated cholesterol increase or cholesterol reduction) SREBP-2-A595G is preferred while for the determination of the risk for the development of a disease which is associated with a higher mortality risk (also independent of an optionally associated cholesterol modification or Alzheimer's disease) all three above further described polymorphisms are suitable whereby SREBP-2-A595G and SREBP-1c-G1028G are preferred.

While polymorphisms of SREBP are in general suitable for the method, SREBP-1 polymorphisms and/or SREBP-2 polymorphisms are preferred, in particular polymorphisms leading to an increased or reduced activation of genes of the lipid metabolism, in particular of the cholesterol metabolism. Polymorphisms leading to a increased or reduced plasma concentration of at least one lipid, in particular cholesterol, are more preferred.

It was found that a polymorphism having a recognition site for a cleavage site which lies within the polymorphism is particularly suitable for a method using said recognition sequence. Such recognition sites are e.g. the recognition sequence for XmnI or MspI, i.e. GAANNNTTC or CCGG, wherein N can be any nucleotide. Sequences comprising such recognition sequences are e.g.

SREBP-1, exon 18c:GCACCTAGGGAAAGGCTTC, (Seq. Id. No. 3) and

SREBP-2, exon 10: CTGCTGCCGGCAACCTACA (Seq. Id. No. 7).

Said sequences either alone or together with further nucleotides of their natural vicinity can e.g. be used as probes. In addition there are further suitable sequences such as the following nucleic acid sequence, optionally together with further nucleotides of the natural vicinity of said sequence, namely

SREBP-2, exon 6: CTGAAGAAG.

A preferred method at nucleic acid level is characterized in that after having taken blood or a tissue sample, respectively, and after DNA extraction at least part of a sequence, in particular of an exon, of a SREBP comprising a polymorphism is amplified using two oligonucleotides wherein said polymorphism is characteristic for an increased or reduced activation of genes of the lipid metabolism, in particular cholesterol metabolism, and particularly preferred for an increased or reduced risk for hypercholesterolemia in humans, and that the product of said amplification is subjected to a digestion with a suitable restriction enzyme or subjected to denaturation and that the product of the digestion or the product of the denaturation, respectively, is electrophoretically separated.

If the polymorphism lies in an exon, preferably at least one of the oligonucleotide sequences lies in the intron range which is adjacent to the exon where the polymorphism is found such as e.g. the pairs

S1.18cF (Seq. Id. No. 9):

5'-TTATTTATAATCTGGGTTTGTGTC-3' and

S1.18cR (Seq. Id. No. 10):

5'-GGGAAGAGCTAAGTTAAAAGTTGTG-3' or

5 **EcoR I.S1.18cF** (Seq. Id. No. 11):

5'-CGGAATTCGAAATTATTTATAATCTGGGTTTGTGTC-3' and

EcoR I.S1.18cR (Seq. Id. No. 12):

5'-CGGAATTCATCGGGAAGAGCTAAGTTAAAAGTTGTG-3' or

S2.10P.F (Seq. Id. No. 13):

10 5'-GCCAGTGACCATTAACACCTTTTGA-3' and

S2.10P.R. (Seq. Id. No. 14):

5'-TCGTCTTCAAAGCCTGCCTCAGTGGCTGGC-3' or

EcoRI S2.10F (Seq. Id. No. 15):

5'-CGGAATTCGCCAGTGACCATTAACACCTTTTGA-3' and

15 **EcoRI S2.10R** (Seq. Id. No. 16):

5'-CGGAATTCGCAGCAAGCCAGTCATCAGCAGCT-3'

EcoRI S2.6F (Seq. Id. No. 17):

5'-CGGAATTCGTGCTCACTGTGTTTTTCACTCATC-3'

EcoRI S2.6R (Seq. Id. No. 18):

20 5'-CGGAATTCGCCAGGGCTGACAAGCCTTTTCTCA-3'.

Besides the above mentioned sequences or sequence pairs, respectively, other sequences or sequence pairs, respectively, can be used such as sequences hybridising to the above mentioned sequences under stringent conditions, including sequences without or with other recognition sequences, respectively, than the above indicated EcoRI sequence. The total length of such sequences is usually 15 to 30 bases.

Suitable polymorphisms can be found by amplifying and analyzing a SREBP sequence of interest, comparing the exon regions of said sequence of interest to the exon regions of the type of sequence of the corresponding SREBP which is most often found in a population and examining sequences with found differences for dysfunction, whereby preferably the differences lead to a different amino acid and/or in particular to an recognition site for a restriction enzyme. Such a recognition site lies

preferably in a exon but said recognition site can as well lie in an intron and e.g. lead to a splice variant.

The big influence of the found polymorphisms on factors influencing various diseases is below discussed by means of the more often occurring polymorphisms A595G and G1028G:

Mutation A595G in the SREBP-2 gene is not associated with a significant modification of the mean plasma cholesterol concentration. The amino acid sequence corresponding to the published cDNA sequence (12,15,16) was defined as wildtype, although - at least in the examined Swiss collective - the sequence coding for glycine at position 595 had a much higher prevalence than the published alanine at this position. More than 93 % of all individuals were heterozygous or homozygous carriers of mutation A595G. Both genes were sequenced from a cDNA library deriving from HeLa cells stemming from a carcinoma of an afro-american woman (Henriette Lacks) (17). Direct experiments with HeLa cells showed that said cells were homozygous with regard to the non-mutated A595G genotype and indicated that said person was a homozygous carrier of the wildtype alleles - a condition which was only found in 6.69 % of the Swiss inhabitants collective. The observation of a high prevalence of mutation A595G led in the scope of the present invention to the hypothesis that the rare wildtype in homozygous form (11) is associated with a higher plasma cholesterol concentration and that the non-mutated form (22) is associated with a lower concentration that thus an autosomal-recessive effect could exist and that therefore allele combination 11 and 12/22 were compared to each other.

The sample of enrolled individuals was heterogeneous with regard to the plasma cholesterol concentration which was in the range of 1.95 to 22.65 mmol/l. Said large range can be explained by the inclusion of random sampling but as well by inclusion of selected collectives and therefore normocholesterolemic and hypercho-

lesterolemic individuals. It was therefore not surprising that without stratification of the sample in random/non-random selected or in normocholesterolemic / hypercholesterolemic subgroups, the effect of at least one of the polymorphisms, polymorphism G1028G, did not achieve statistical significance ($P=0.777$). Similarly, for mutation A595G the probability that differences of the plasma cholesterol concentrations between the allele combination 11 compared to 12/22 is by chance was reduced from $P=0.0003$ (unpaired t-Test, no stratification) to $P<0.0001$ (analysis of variance = ANOVA, stratification).

Moreover, for both polymorphisms the associations between a defined allele combination and higher plasma cholesterol concentrations (allele combination 22 of polymorphism G1028G, allele combination 11 of polymorphism A595G; depicted in black in figure 3, E and F) were stronger in presence of polymorphism R158C ($\epsilon 2$ phenotype) and were weaker in absence of polymorphism C112R ($\epsilon 4$ phenotype) in the apo E gene. It was found that said gene-gene interactions clearly influence the association of polymorphism G1028G (allele combination 22) with higher plasma cholesterol concentrations: after exclusion of the carriers of mutation C112R the effect of mutation G1028G C \rightarrow G in homozygous form (22) was highly significant ($P=0.0002$).

It was therefore possible to show that both SREBP genes modify plasma cholesterol concentrations in humans similarly to the known effects of both polymorphisms in the apo E gene (C112R and R518C). Furthermore, gene-gene interactions became obvious when SREBP-1 and SREBP-2 gene polymorphisms were correlated with the polymorphisms of the apo E gene.

The plasma triglyceride levels were elevated in 11.6 % of the individuals with secondary hyperlipoproteinemia. An effect of elevated triglyceride concentrations is underlined by the fact that, if individuals with elevated triglyceride concentrations were excluded, muta-

tion A595G had a significant effect on male individuals with diabetes mellitus ($P=0.0018$), but said effect was not observed when individuals with elevated triglyceride concentrations were included.

5 Mutation A595G in the SREBP-2 gene could be closely correlated both with another mutation and directly affect the cleavage rate of the protein. Though exon 10 where mutation A595G is localized does not belong to the part of the mature protein that migrates to the
10 cell nucleus. Nevertheless, said part of the protein is connected with the activity of the protein by influencing the cleavage reactions which activate the precursor of SREBP-2.

Proteolysis is initiated by a protein recog-
15 nizing a highly conserved RXXL sequence of the SREBP precursors which is localized in the hydrophilic loop. The first proteolysis step separates the NH_2 -terminal domain and the COOH -terminal domain. After said first sterol sensitive step, the remaining membrane bound NH_2 terminal
20 fragment is released by a second sterol independent step. Said second proteolysis step (site 2) is localized within the membrane spanning region and is mediated by the site-2 enzyme. Said second step only occurs when site-1 proteolysis has occurred. However, a precondition for site-1
25 proteolysis is the formation of a complex of SREBP and the so called SREBP cleavage activating protein (SCAP). When the sterol level is low in cells, said protein binds to the COOH terminal domain. The formation of the SREBP-SCAP complex is crucial for the site-1 proteolysis step
30 and is dependent on the integrity of the COOH terminal domain of SREBP-2 and SCAP (18,19). On the basis of experiments recently performed by Sakai et al. (18) which identified the C-terminal part of SREBP precursors as regulatory unit, the mutation in said domain which causes
35 a significant reduction of the average plasma cholesterol concentration, raises the question of a slightly facili-

tated formation of the SREBP-SCAP complex when mutation A595G is present.

The effect of polymorphism G1028G seems to be influenced by the gene-gene interactions with the apo E gene. In contrary to mutation G1028G in the SREBP-1 gene, mutation A595G in the SERBP-2 gene has as marker significant effects on the plasma cholesterol concentrations both when the whole collective is examined and when the different subgroups are analyzed. It is probable that the mutation shows its effect by directly influencing the cleavage reaction which is responsible for the sterol dependent activation of SREBP-2.

From the above comment ensues that both genes significantly modify the individual plasma cholesterol concentrations. Although many genes play a role in the intracellular and extracellular cholesterol metabolism, until now only the apo E gene as modifying gene has been of bigger use with regard to the general population. Other genes involved in the lipoprotein metabolism such as the LDL receptor gene, the apo B-100 gene or a further unknown gene on chromosome 1p34.1-p32 could have a significant effect on plasma cholesterol concentrations in their mutated state. However, said mutations are very seldom compared to the polymorphisms in the apo E gene and the polymorphisms in the SREBP-1 gene and SREBP-2 gene which were now discovered. Even mutation R3'500Q which has so far the highest observed prevalence with 209 affected individuals of the general population (in Switzerland) does not occur often enough in order to examine the influence of a defined gene on the cholesterol metabolism of the general population using said polymorphism.

The methods and polymorphisms of the present invention are therefore very valuable tools for the early detection of risk patients as well as for the optimization of prophylaxis and therapy. Furthermore, said polymorphisms are suitable targets for drug screening as well

as the evaluation of a therapy for a disease such as e.g. HIV. The value of the preferred polymorphisms of the present invention is also the presence of recognition sites in closest proximity to the polymorphism. Said recognition sequences are in SREBP-1 the recognition sequence for XmnI, namely GAANNNTTC, wherein N can be any desired nucleotide and in SREBP-2 the recognition sequence for MspI i.e. CCGG.

The present invention relates also to a method for the detection of risk carriers as well as to means for said methods such as oligonucleotide sequences for the amplification of DNA regions of interest.

A preferred method for the detection of risk carriers is characterized by the following steps.

1. Taking a blood or tissue sample
2. DNA extraction
3. Amplification with suitable primers
4. Digestion with suitable restriction enzymes or denaturation of the PCR products
5. Electrophoretical separation with a suitable gel

In particular the polymorphisms of special interest are detected by means of digestion with suitable restriction enzymes and further mutations can be found by means of denaturation (single stranded conformation polymorphism = SSCP).

A preferred oligonucleotide sequence for the amplification of a DNA region which corresponds to an exon region where a polymorphism is found, is characterized in that said oligonucleotide sequence lies in an intron region which is adjacent to the exon where the polymorphism exists and close to the exon/intron boundary or lies in the exon provided that thereby the number of cleavage sites is reduced.

Preferred oligonucleotides for the SREBP-1 polymorphism are the oligonucleotides S1.18cF (Seq. Id. No. 9): 5'-TTATTTATAATCTGGGTTTGTGTC-3' and S1.18cR (Seq.

Id. No. 10): 5'-GGGAAGAGCTAAGTTAAAAGTTGTG-3', which allow the detection of splice variants, as well as oligonucleotides, which further comprise additional *EcoR* I-cleavage sites such as *EcoR* I.S1.18cF (Seq. Id. No. 11): 5'-CGGAATTCTGAAATTATTTATAATCTGGGTTTGTGTC -3' and *EcoR* I.S1.18cR (Seq. Id. No. 12): 5'-CGGAATTCATCGGGAAGA-GCTAAGTTAAAAGTTGTG-3'. In order to amplify exon 10 inclusive its exon/intron border the oligonucleotides S2.10P.F (Seq. Id. No. 13):5'-GCCAGTGACCATTAAACACCTTTTGA-3' and S2.10P.R (Seq. Id. No. 14):5'-TCGTCTTCAAAGCCTGCCTCAGTG-GCTGGC-3' or *EcoRI* S2.10F (Seq. Id. No. 15): 5'-CGGAATTTCGCGCAGTGACCATTAAACACCTTTTGA-3' and *EcoRI* S2.10R (Seq. Id. No. 16): 5'-CGGAATTCTGCAGCAAGCCAGTCATCAGCAGCT-3' are preferred.

A particular use of SREBP polymorphisms relates to their application in so called DNA or gene chips. Methods using said chips which allow the simultaneous detection of various gene defects are described in the literature. There is information material from the company Affymetrix concerning their GeneChip™ systems but there are as well publications in scientific journals such as the publication of Mark Chee et al., Accessing Genetic Information with High-density DNA Arrays, Science Vol. 274, p. 610-4, (1996) and David G. Wang, Large scale Identification, Mapping, and Genotyping of Single nucleotide polymorphisms in the human Genome, Science Vol. 280, p. 1077-82, (1998).

The method can briefly be summarized as follows: By means of photo lithography defined areas of a wafer are fed stepwise to the chemical synthesis of single stranded DNA or RNA wherein the protective film is renewed after each synthesis step followed by the selective removal of said protective film from sites where a defined nucleotide should be added. This procedure allows the production of areas which are selective for defined polymorphisms. Common labels can be used for the visualization of hybridization with target sequences e.g. light

emitting labels such as e.g. biotinylation and detection with streptavidin or fluorescence labels.

By means of removal of labeled non-hybridized fragments hybridisations are directly visible or after a further treatment. It is self-evident that the single steps of the method can be varied e.g. with regard to the time point of labeling or the kind of labeling. This kind of variations are known to a man skilled in the art.

A chip which is suitable for the early detection of patients with an increased risk for hypercholesterolemia comprises besides the normal SREBP-1 and SREBP-2 sequences the corresponding polymorphisms which are an object of the present invention. It is obvious that besides said SREBP-1 and SREBP-2 means for analysis also the corresponding sequences for further polymorphisms which are characteristic for hypercholesterolemia i.e. FH, FDB and FDL can be present.

It is obvious that a corresponding chip can also be used for the diagnosis of other diseases which show a dependency on SREBP-1 and/or SREBP-2 such as Alzheimer's disease or said chip can be constructed for the diagnosis of several diseases or risk factors by fixing polymorphisms characteristic for the diseases or risks of interest to said chip. Sequences of interest are e.g. for the studies of cardiovascular risks, sequences of the following group (preferred sequences are underlined):

11 β -Hydroxylase Aldosteron-Synthase Gene,
11 β -Hydroxysteroid-Dehydrogenase (HSD11K)Gene, 17 α -
Hydroxylase (CYP17A)Gene, 3-Hydroxy-3-Methylglutaryl
(HMG)Coenzyme A Reduktase Gene, 3-Hydroxy-3-
Methylglutaryl (HMG)Coenzyme A Synthase Gene, Acyl Coen-
zyme A:diacylglycerol acyltransferase Gene, Acyl-Coenzyme
A:cholesterol acyltransferase (ACAT)-1 Gene, Alpha-1-
Antichymotrypsin Gene, Alpha-1-trypsin Gene, Alpha-
Glaktosidase A Gene, Alpha-L-Iduronidase (IDUA) Gene, Al-
pha-Lecithin cholesterol acyltransferase (LCAT) Gene, Al-
pha-Synuclein Gene, Angiotensin Gene, Angiotensin II Typ

- 1 Rezeptor Gene, Angiotensin-converting Enzym Gene, Anti-
trypsin Gene, Apolipoprotein (a) Gene, Apolipoprotein AI-
CIII-AIV Gene cluster, Apolipoprotein B-100 Gene, Apo-
lipoprotein CI Gene, Apolipoprotein E (epsilon 2), Apo-
5 lipoprotein E (epsilon 4), Apolipoprotein E Gene, Apo-
lipoprotein E Rezeptor 2 Gene, Benzodiazepine Receptor
Gene, CD-36 Gene, Cholesterol 24-Hydroxylase Gene, Cho-
lesteryl ester transfer Protein (CETP) Gene, Cysta-
thionin- β -Synthase Gene, Cystatin C Gene, Cytochrome P450
10 cholesterol side-chain cleavage Enzyme Gene, Epithelial
Na⁺-channel (β -subunit) Gene, Farnesyl-Pyrophosphate (FP)
Synthase Gene, Fibrinogen Gene, Glucokinase Gene, GLUT1
Glucose Transporter Gene, Hepatic Lipase Gene, High den-
sity lipoprotein (HDL) Receptor Gene, Homogentisinacid-
15 Oxidase Gene, Hormone-sensitive Lipase Gene, Iduronat-2-
Sulfatase Gene, Interleukin-8 Gene, Lecithin cholesterol
acyltransferase (LCAT) Gene, Lipooxygenase Gene, Lipopro-
tein Lipase Gene, Low density lipoprotein receptor-
20 related Protein (LRP) Gene, Low density lipoprotein Re-
ceptor Gene, Lysosomale acid Lipase Gene, Macrophage
Scavenger Receptor (SR-A) Gene, Macrophage Scavenger Re-
ceptor (SR-BI) Gene, Methylene-tetrahydrofolate Reduktase
Gene, Microsomal triglyceride transfer Protein (MTP)
Gene, NF- κ B Gene, Niemann-Pick C1 Protein Gene, Oxysterol
25 binding Protein (OSBP) Gene, Paraoxonase-1 Gene,
Paraoxonase-2 Gene, Peroxisome proliferator-activated re-
ceptor (PPAR) alpha Gene, Peroxisome proliferator-
activated receptor (PPAR) beta Gene, Peroxisome prolif-
erator-activated receptor (PPAR) gamma Gene, Plasminogen
30 activator-inhibitor-1 Gene, Site-1 Protein (S1P) Gene,
Site-2 Protein (S2P) Gene, Squalene Synthase Gene, SREBP
cleavage-activating Protein (SCAP) Gene, Steroid acute
regulatory Protein (StAR) Gene, Steroid-11 β -Hydroxylase
(CYP11B1) Gene, Sterol-27-Hydroxylase Gene, Sterol re-
35 gulatory element-binding protein (SREBP)-1a Gene, Sterol
regulatory element-binding protein (SREBP)-1c Gene,

Sterol regulatory element-binding protein (SREBP)-2 Gene,
Very low density lipoprotein (VLDL) Receptor Gene.

- For the studies of neurological risks for example a chip comprising sequences of the below mentioned
5 group is suitable (preferred sequences are underlined):

- A-beta precursor Gene, Adenosine monophosphate deaminase Gene, Alpha 2-monoglobulin Gene, Alpha-1-Antichymotrypsin Gene, Alpha-1-trypsin Gene, Alpha-2 Macroglobulin Gene, Alpha-ketoglyterate dehydrogenase Gene,
10 Amyloid beta-protein precursor Gene, Amyloid precursor Protein Gene, Amyloid precursor-like Protein 1 Gene, Amyloid precursor-like Protein 2 Gene, Antitrypsin Gene, Apolipoprotein (a) Gene, Apolipoprotein AI-CIII-AIV Gene cluster, Apolipoprotein E (epsilon 2), Apolipoprotein E (epsilon 4), Apolipoprotein E Gene, Apolipoprotein E Receptor 2 Gene, Bcl-2 Gene, Beta-amyloid precursor Protein Gene, Beta-nerve growth factor Gene, Calbindin-D Gene, Catpase Gene, Cathepsin D Gene, CD36 Gene, Clusterin Gene, Cyclooxygenase-2 Gene, Cystatin C Gene, Cytochrome
20 C Oxidase 1 Gene, Cytochrome C Oxidase 2 Gene, Cytochrome Oxidase Gene, Dihydrofolate Reduktase Gene, Dihydro-lipoylsuccinyltransferase (DLST) Gene, Endopeptidase 1 Gene, Estrogen-Bcl xL Gene, Fe65L2 Gene, Gamma-synuclein Gene, Gelsolin Gene, GLUT1 Glukose Transporter Gene,
25 GLUT4 Glucose Transporter Gene, Glutaminacid Decarboxylase Gene, Glutation S-transferase Gene, HLA-A2 Gene, Interleukin-1 Gene, Interleukin-6 Gene, Interleukin-8 Gene, L-3-Hydroxyacyl-Coenzym A Dehydrogenase Gene, Li-pooxygenase Gene, Low density lipoprotein receptor-related Protein (LRP) Gene, Low density lipoprotein Receptor Gene, Macrophage Scavenger Receptor (SR-A) Gene, Macrophage Scavenger Receptor (SR-BI) Gene, Methylene-tetrahydrofolate Reduktase Gene, Myeloperoxidase Gene, NF- κ B Gene, Niemann-Pick C1 Protein Gene, Non-A-beta component for amyloid (NAC) peptide Gene, Notch Gene, Or-nithine transcarbamyase Gene, Presenilin 1 Gene, Presenilin 2 Gene, Prion Protein Gene (PRNP) Gene, Prostaglan-

1
din E2 Gene, Serotonin Gene, Serotonin Transporter Gene,
Site-1 Protein (S1P) Gene, Site-2 Protein (S2P) Gene,
SREBP cleavage-activating Protein (SCAP) Gene, Sterol
regulatory element-binding protein (SREBP)-1a Gene,
5 Sterol regulatory element-binding protein (SREBP)-1c
Gene, Sterol regulatory element-binding protein (SREBP)-2
Gene, Superoxid dismutase gene, Tau (Protein) Gene, Very
low density lipoprotein (VLDL) Receptor Gene, X11alpha
Protein Gene, X11L2 Gene.

10 Furthermore, the polymorphisms, methods and
chips of the present invention are also suitable to de-
tect possible risk patients for the treatment with spe-
cial medicaments such as a treatment with protease in-
hibitors in case of HIV infected individuals.

15 The present invention is now further illus-
trated by means of examples. It is to be distinctly un-
derstood that the invention is not limited to the exam-
ples described in the experimental part or limited to the
explicitly mentioned embodiments therein, respectively.

20 **Experimental part**

25 Preliminary remarks

30 The polymorphisms were detected by synthesiz-
ing oligonucleotides to intron sequences of the exon/ in-
tron boundary so that also possible splice variants could
be detected. Below the detailed procedure for the detec-
tion of relevant polymorphisms as well as their examina-
tion is described.

Subjects

35 A total of 3'078 subjects were enrolled in
the study. DNA polymorphisms and rare mutations in five
different genes were screened. In all groups of subjects,

individuals with TC plasma concentrations below the 90th percentile, standardized for age and gender, were classified as normocholesterolemic (NC); individuals with TC plasma concentrations above the 90th percentile, as hypercholesterolemic (HC). 1'685 were enrolled from different, prospectively studied random samples. 630 individuals were collected from the "Swiss PREvalence for Apolipoprotein Defects" (SPREAD) study, a large, cross-sectional survey which included unrelated male individuals from the German, French, and Romansh speaking parts of Switzerland who had been recruited for military service. Another 324 individuals were enrolled from the "Inter-Disciplinary study on Aging" (IDA). Another 413 elderly individuals who had been collected because of a potential impairment of their memory function but not because of hypercholesterolemia were enrolled from the Basel Memory Clinics (BMC) as a further control sample. In addition, 318 affected and/or unaffected individuals were from the "Study to Investigate the molecular Basis of hypercholesterolemia in Switzerland in Hyperlipidemic Individuals by Pedigree analysis" (SIBSHIP), a substudy of the Swiss MED PED (Make Early Diagnosis - Prevent Early Death) program, the latter being a multinational program endorsed by the WHO. 871 individuals were from samples collected because of potential primary and secondary hyperlipoproteinemias. The molecular diagnosis was based on the identification of the underlying mutation (familial defective apo B (FDB), familial dysbetalipoproteinemia (FDL), familial hypercholesterolemia, diagnosed molecularly or by cosegregation analysis (FHM)). The clinical diagnosis of familial forms of hyperlipoproteinemia was based on total and/or LDL cholesterol levels above the 90th percentile, and a family history with at least two further family members with hypercholesterolemia. Individuals from families with these characteristics and triglyceride levels < 3.7 mmol/L and/or tendon xanthomas were classified as having familial hypercholesterolemia, clinically diag-

nosed (FHC). Families with individuals without xanthomas and triglyceride levels ≥ 3.7 mmol/L were classified as having familial combined hyperlipidemia (FCH).

A total of 298 subjects were from the "Study on the molecular basis of Triggers Activating a Rise in Triglycerides and cholesterol in Endocrinological and Renal Diseases" (STARTER). A sample of 130 individuals with biochemically confirmed diabetes mellitus (fasting plasma blood glucose >7.8 mmol/L) (DIA), 78 individuals with hypothyroidism, and 14 individuals with renal insufficiency (creatinin clearance < 50 ml/min) (RIN) were also enrolled in the study.

In all subjects at least age, gender, and total cholesterol concentrations prior to therapy with lipid-lowering drugs, and the clinical or molecular biological diagnosis, respectively, were assessed. Except for the SPREAD study, subjects were, in addition, clinically extensively characterized. In the IDA, BMC, SIBSHIP and STARTER studies height, weight, body mass index, blood pressure, the presence or absence of the clinical signs of hypercholesterolemia (xanthomas, xanthelasms, and arcus lipoides) and signs and symptoms of coronary heart disease, cerebrovascular diseases, and peripheral artery disease, as well as biochemical parameters such as plasma concentrations of total cholesterol, LDL cholesterol, HDL cholesterol, triglycerides, and thyroid-stimulating hormone (TSH) were assessed. The documentation included also the personal history of coronary heart disease, cerebrovascular disease, and peripheral artery disease, thyroid disorders, diabetes mellitus, daily intake of alcohol, and cigarette smoking (pack years), and in the SIBSHIP and STARTER studies a detailed family history with additional lipoprotein analyses (e.g. lipoprotein(a) [Lp(a)], apolipoprotein B, etc.).

In all these subjects, samples were anonymized for further laboratory testing and analysis.

Materials

Thermus aquaticus DNA polymerase and deoxynucleotides were purchased from Perkin Elmer Cetus Corporation (Norwalk, CT, USA), and from Qiagen (Milden, Germany). Restriction endonucleases were from New England Biolabs Inc. (Beverly, MA, USA) and prestained protein molecular weight markers and DNA molecular weight markers were from Roche Diagnostics (Basel, Switzerland). The oligonucleotides used were synthesized by Microsynth Inc. (Balgach, Switzerland). DNA was amplified in 200 μ l tubes using thermocyclers of Perkin Elmer (GeneAmp[®] PCR System 9700) and of Stratagene (RoboCycler[®] Gradient 96 Temperature Cycler, Stratagene, La Jolla, CA, USA). Agarose was purchased from BioRad (Irvines, CA, USA) and polyacrylamide (acrylamide: bisacrylamide 37.5:1) from Oncor Inc. (Gaithersburg, MD, USA). Precast GMA[™] Wide Mini S-50 gels and Spreadex EL 300 Wide Mini S-100 gels were purchased from Elchrom Scientific (Cham, Switzerland). Precast gels for polyacrylamide gel electrophoresis (Ready Gels 10%) were obtained from BioRad. [α -³²P] dCTP and Hybond-C extra nitrocellulose membranes were obtained from Amersham International (Buckinghamshire, UK). DH5 α bacteria and 1 kb DNA ladders were purchased from GIBCO BRL, Life Technologies (Paisley, UK). QIAmp 96 DNA blood kits, Genomic tip kits, QIAquick Extraction and PCR purification kits, QIAprep Spin Miniprep kits, and QIAGEN Plasmid Midi kits were from Qiagen.

Methods

Individuals enrolled were screened for two known DNA polymorphisms in the apo E gene both causing amino acid substitutions (C112R, R158C), for a highly prevalent DNA mutation in the Swiss population located in the apo B-100 gene causing an amino acid substitution (R3'500Q), for a novel DNA polymorphism in the SREBP-1

gene (G1028G) which does not lead to an amino acid substitution, and for a novel polymorphism in the SREBP-2 gene leading to an amino acid substitution (A595G). A subset of these subjects where further family members with hypercholesterolemia had been studied (SIBSHIP study), was tested for the presence of DNA restriction fragment length polymorphisms in the LDLR gene, which allowed us to perform cosegregation studies for confirmation of LDLR defects. Subjects from the SIBSHIP study were, in addition, systematically screened for mutations in the LDLR gene.

1. Lipoprotein analyses

Fasting blood samples were taken from the subjects enrolled in the study. Lipid and lipoprotein analyses were performed at the Central Laboratory, University Clinics, Basel, except for a small subset of subjects from the SHIBSHIP study with familial forms of hyperlipoproteinemias who had already been treated at study entry; in these cases a wash-out period could not be performed for ethical reasons. In this subset of patients, total cholesterol concentrations were determined at the Central Laboratory prior to the beginning of drug treatment, or pretreatment total cholesterol concentrations partly determined at other laboratories were obtained from their general practitioners and included into the analysis. LDL cholesterol (LDLC) was precipitated with heparin (Merck, Darmstadt, Germany) and subsequently calculated using the Friedewald formula. HDL cholesterol (HDL) was precipitated by means of phosphotungstic acid and magnesium ions (Roche Diagnostics). Total cholesterol, LDLC, and HDLC plasma concentrations were measured by the enzymatic colorimetric cholesterol 4-aminophenazone (PAP) method (Roche Diagnostics) on a Hitachi analyzer model 737.

2. DNA extraction method

Total genomic DNA from the subjects enrolled in the study was extracted from white blood cells by the salting out method (1) with modifications as described previously (2), or by using the QIAmp™ 96 DNA Blood kits (Qiagen).

3. Single-Strand-Conformation Polymorphism

10 (SSCP)

a) Radioactive Method

To screen for LDLR gene mutations, all 18 exons of the LDLR gene were amplified using oligonucleotides published by Hobbs et al. (3).

To amplify exon 18c of the SREBP-1 gene including its exon/intron boundaries allowing to detect splice site mutations as well, the following pair of oligonucleotides was used:

S1.18cF (Seq. Id. No1 9): 5'-TGAAATTATTTATA-ATCTGGGTTTTGTGTCTT-3' and

S1.18cR (Seq. Id No. 10): 5'-CATCGGGAA-GAGCTAAGTTAAAAGTTGTG-3'.

To amplify exon 10 of the SREBP-2 gene including its exon/intron boundaries, the oligonucleotides

EcoR I S2.10F (Seq. Id. No. 15): 5'-CGGAATTGCCAGTGACCATTAAACACCTTTTGA -3' and

EcoR I S2.10R (Seq. Id. No. 16): 5'-CGGAATTCTGCAGCAAGCCAGTCATCAGCAGCT-3' were used. PCR was performed in a final volume of 6 µl in 1x PCR buffer (Perkin Elmer) using 1.0 U Taq polymerase (Qiagen), 74 kBq [α -³²P]dCTP (Amersham) and final concentrations of 1.5 mM MgCl₂, 420 µM of each of the four dNTPs (Qiagen), and 8.3 µM of each of the two oligonucleotides.

For SSCP of the LDLR gene, genomic DNA (200ng) was amplified under the following PCR conditions:

95°C, 180 sec. (1 cycle); 95°C, 45 sec.; 58°C, 30 sec.,
72°C, 120 sec. (29 cycles).

For SSCP of the SREBP-1 and SREBP-2 genes,
genomic DNA (200ng) was amplified under the following PCR
5 conditions: 95°C, 180 sec. (1 cycle); 95°C, 60 sec.;
58°C, 30 sec., 72°C, 60 sec. (30 cycles). Following PCR,
25 µl of denaturing buffer (95% formamide, 0.05% bromophe-
nol blue, 0.05% xylencyanol, 20 mM EDTA) were added to
the PCR mix. After 5 min. of denaturation at 95°C, 6µl of
10 the mix was loaded on a 7% polyacrylamide gel (ac-
rylamide: bisacrylamide mix 37.5:1), 2xTBE, 1.37M glyc-
erol, gel thickness 0.75 mm) and the gel was run with
1xTBE buffer at 4°C in a cold room or at room tempera-
ture, at 15-20 V/cm for 12-16h. Subsequently, the gel was
15 dried under vacuum at 80°C for 1h and Kodak X-OMAT AR
films were exposed for 3-36h at room temperature.

b) Non-radioactive Method

20 For non-radioactive detection of sequence
variations in exon 10 of the SREBP-2 gene including its
exon/intron boundaries, the oligonucleotides *EcoR* I
S2.10F and *EcoR* I S2.10R were used. PCR was performed in
a final volume of 11µl in 1x PCR buffer (Qiagen) using
25 1.0 U *Taq* polymerase (Qiagen) and final concentrations of
1.5 mM MgCl₂, 909 µM of each of the four dNTPs (Qiagen),
and 4.6 µM of each of the two oligonucleotides. Genomic
DNA (100ng) was amplified under the following conditions:
95°C, 180 sec. (1 cycle); 95°C, 60 sec.; 58°C, 30 sec.;
30 72°C, 60 sec. (29 cycles). Following PCR, 25µl of dena-
turing or loading buffer, respectively, (97% formamide,
0.05% bromophenol blue, 0.05% xylencyanol, 10mM NaOH) were
added to the PCR mix. After 5 min. of denaturation at
92°C and immediate chilling on ice for 10 min., 6µl of
35 the mix were loaded on Elchrom GMA Wide Mini S-50 gels,
and run with 1x TAE buffer (9°C buffer temperature) at 6
V/cm in an Elchrom Sea 2000 Submarine Electrophoresis Ap-

paratus for 14 h. After removal of its backing, the gel was stained for 40 min. in 50 ml of SYBR[®] Gold (working solution according to the manufacturer, Molecular Probes) in 0.75 x standard TAE buffer (4) on a shaker. Followed by destaining for 40 min. in 100 ml of distilled water by shaking, the gel was analyzed and digitalized using 302 nm UV transillumination on a Gel Doc 1000 system (Bio-Rad).

4. Sequencing of Mutations in the LDLR Gene and of Mutations in SREBP-1, Exon 18c, and SREBP-2, Exon 10

The detected sequence variations were further analyzed by subcloning of the amplified exons and subsequent sequencing of the insert. In the LDLR gene, PCR amplification of the respective exons was performed using the oligonucleotides described above (3). In the SREBP-1 gene, PCR amplification of exon 18c was carried out using oligonucleotides containing additional *Eco* R I restriction sites;

Eco R I.S1.18cF (Seq. Id. No. 11): 5'-CGGAATTCTGAAATTATTTATAATCTGGGTTTGTGTC -3' and

Eco R I S1.18cR (Seq. Id. No. 12): 5'-CGGAATTCATCGGGGAAGAGCTAAGTTAAAGTTGTG-3'. In the SREBP-2 gene, PCR amplification of exon 10 was carried out using *Eco* R I.S2.10F: and *Eco* R I.S2.10R.

Amplification reactions were performed in a final volume of 50 μ l in 1xPCR buffer (Qiagen) using 2.5 U *Taq* polymerase (Qiagen) and final concentrations of 1.5 mM MgCl₂, 500 μ M of each of the dNTPs (Qiagen) and 2.0 μ M of each of the two oligonucleotides. The following temperatures were reached on a RoboCycler[®]: 95°C, 45sec.; 58°C, 30 sec.; 72°C, 45 sec. (30 cycles).

The amplified fragments (50 μ l) were loaded on a 1% agarose gel containing 0.6 μ g/ml ethidium bromide, cut out of the gel, and purified using the QIAquick[™] Ex-

traction kit (Qiagen). The DNA fragment was digested with 20 U *EcoR* I for at least 3 h and purified using the QIAquick™ PCR purification kit. The vector pcDNA 3.1 His A (3-5 µg) was digested with 40 U *EcoR* I for 3 h. Subsequently, 20 U of calf intestinal peptide (Roche Diagnostics) were added and incubated for 1 h at 37° C. The vector was purified using the QIAquick™ PCR purification kit and eluted with 50 µl water. Ligation was performed using the ligation kit of Takara. The purified PCR product (4µl) and the purified pcDNA3.1 His A vector (1µl) were ligated according to the manufacturer and transformed into *E.coli* DH5α bacteria (Life Technologies) by using the heat shock method (42° C for 45 sec.). From subjects with the wild type according to the SSCP results and from subjects with the sequence variation, 5-7 colonies were selected and resuspended in 10 µl of water. Genotypization for the presence of the sequence variation was performed using 2µl of the bacterial suspension and the SSCP methods as described above. Independent clones of each of the two condition (wild type/mutation) from two independent PCR reactions were sequenced. DNA sequencing was performed by Microsynth Inc. using the dideoxy chain termination method. For expansion of the clones, 5 µl of the remaining suspension were added to 3ml of LB medium containing 100 µg/ml ampicillin and incubated at 37° C overnight. From 1.5 ml of the bacterial suspension, plasmid DNA was purified using the QIAprep™ Spin Miniprep kit (Qiagen).

5. Testing for apolipoprotein E mutations known to modify the plasma cholesterol concentration

The two frequent apo E aminoacid polymorphisms C112R and R158C were identified by PCR amplification and subsequent digestion with *Hha* I or its isochizomer *Cfo* I according to the protocol of Hixson and Vernier (5).

6. Testing for apolipoprotein B mutations known to modify the plasma cholesterol concentration

Three different molecular assays were used to screen for mutations causing an amino acid substitution at position 3'500 of the apo B gene. Samples of subjects from the SPREAD study(2) with total cholesterol concentrations ≤ 4.5 mmol/L were pooled (25 samples) and screened for mutations using the methods of Ruzicka et al., 1992 (6) and of Schuster et al. (7). Subjects with total cholesterol concentrations > 4.5 mmol/L and positive pools in the SPREAD study as well as all the other samples investigated until 1996 were tested individually using allele-specific, asymmetric PCR as described previously (2). Starting from 1996, this method was replaced by a site-directed mutagenesis PCR technique introducing an *Msp* I restriction site in the wild-type samples. Subsequent digestion with *Msp* I (8) revealed subjects affected by the R3'500Q mutation.

7. Methods to Identify the Polymorphisms in Exon 18c of SREBP-1 and Exon 10 of SREBP-2 by Restriction Enzyme Digestion

In the SREBP-1 gene, the entire exon 18c containing the polymorphism which creates a variable *Xmn* I restriction site was amplified using the primer pair S1.18cF and S1.18cR.

In the SREBP-2 gene, only the 5' part of exon 10 containing the polymorphism which creates a variable *Msp* I restriction site was amplified. Thus, we could prevent that further *Msp* I sites were amplified and avoid a complex restriction pattern. In the SREBP-2 gene, the following oligonucleotides were used:

S2.10P.F (Seq. Id. No. 13) 5'-GCCAGTGACC-ATTAACACCTTTTGA -3' and

S2.10P.R (Seq. Id. No. 14) 5'-TCGTCTTCAAA-
GCCTGCCTCAGTGGCTGGC-3'.

To detect the SREBP-1 polymorphism 80 ng genomic DNA from the individuals studied were amplified under the following PCR conditions: 95° C, 240 sec. (1 cycle); 95°C, 60 sec.; 55°C, 60 sec.; 72°C, 90 sec. (33 cycles). In a total volume of 25 µl, 2.0 µM of each of the two oligonucleotides, 400 µM of each of the dNTPs (Qiagen), 1x PCR buffer (1.5 mM MgCl₂, final concentration, Perkin Elmer), and 0.6 U Taq polymerase (Qiagen) were mixed. Of the unpurified amplicon, 20µl were digested in 1x NE buffer using 16-32 U of *Xmn* I (New England Laboratories), 0.2 µl 10mg/ml of BSA, and an incubation temperature of 37°C for 5h.

For the SREBP-2 polymorphism approximately 100 ng genomic DNA were PCR-amplified under the following conditions: 95°C, 30 sec.; 58°C, 30 sec.; 72°C, 90 sec. (30 cycles). In a total volume of 25 µl, 1.37 µM of each of the two oligonucleotides, 390 µM of each of the dNTPs (Qiagen), 1xPCR buffer (1.5 mM MgCl₂, final concentration, Perkin Elmer), and 0.75 U Taq polymerase (Qiagen) were mixed. Of the resulting amplicon, 20 µl were digested in 1x NE buffer using 16 U of *Msp* I and an incubation temperature of 37°C for 5h.

For the identification of the two polymorphisms, 6 - 8 µl of the digested reaction mixes were loaded on 10% polyacrylamide Ready Gels (BioRad) and run with 1x TBE buffer at room temperature at 18-22 V/cm for 25-35 min. The gels were subsequently stained in a 50ml 0.5 µg/ml ethidium bromide solution for 5 min. and digitalized on a Gel Doc 1000 system from BioRad at 302 nm UV transillumination.

8. Testing for LDL Receptor Mutations as a Cause for Increased Plasma Cholesterol Concentrations

In a subset of 48 individuals the clinical diagnosis of familial hypercholesterolemia caused by an LDLR defect was confirmed by cosegregation studies using ten different RFLPs in the LDLR gene (9,10). In 110 of a total of 446 kindreds, all exons of the LDLR gene were investigated using SSCP (radioactive method) and the published oligonucleotides (3). In 22 kindreds the presence of LDLR mutations was confirmed by subcloning and sequencing the exons containing the respective sequence variations.

9. Statistical Analysis: Population Genetics

Data from the Geneva Survey, a study in schoolchildren (13), and data from the Swiss MONICA study (including 3'341 individuals (14)), were used to assess age and gender-specific 90th percentiles for total cholesterol and triglycerides in Switzerland. All calculations were performed on Macintosh G3 computers using the File-Maker® Database CARDIOFILE, the StatView® and SuperANOVA® programs.

Subjects having plasma cholesterol concentrations below the 90th percentile were classified as normocholesterolemic (NC), subjects having total cholesterol concentrations above the 90th percentile were classified as hypercholesterolemic (HC). For both groups, the influence of the presence of the Apo E C112R and R158C mutations, and the novel amino acid polymorphisms in the SREBP-2 gene (A595G) and in the SREBP-1 gene (G1028G) were assessed using multivariate analysis.

10. Evaluation of the results obtained according to the above mentioned indications

10.1. Association of Polymorphisms in the SREBP-1 and -2 Genes with Plasma Cholesterol Levels

10.1.1. Detection of Mutations in the SREBP-1 and -2 Genes with PIC-values Above 0.25

A sample of subjects was investigated for the presence of sequence variations using the single-strand-conformation polymorphism method (SSCP). Our aim was to detect polymorphisms whose prevalence was high enough to allow analyses by population genetics methods. For that purpose we defined a Polymorphism Information Content (PIC) - value above 0.25. Two sequence variations, one in exon 18c of the SREBP-1 gene and one in exon 10 of the SREBP-2 gene, detected by SSCP, fulfilled this requirement and were further characterized. Exon 18c of the SREBP-1 gene and exon 10 of the SREBP-2 gene were amplified in subjects having the respective SSCP patterns differing from the wild-type. These exon sequences were subcloned and sequenced.

Figure 1A shows the chromatogram of a subject having a DNA polymorphism at the amino acid position 1028 in exon 18c of the SREBP-1 gene (G1028G). Figure 1B shows the chromatogram of a subject having a DNA polymorphism causing an amino acid substitution at position 595 of the SREBP-2 (A595G).

In the SREBP-1 gene, a base substitution C → G in exon 18c was discovered. This base substitution does not lead to an amino acid exchange, but generates an *Xmn* I restriction site (Figure 1A). In the SREBP-2 gene, a base substitution C → G was detected. This base substitution leads to an exchange of alanine by glycine in the amino acid sequence and generates an additional *Msp* I restriction site (Figure 1).

The corresponding PIC - values, calculated from all the subjects enrolled except the related individuals from the SIBSHIP study (N=2'446), were 0.368 for the SREBP-1 gene polymorphism and 0.300 for the SREBP-2 gene polymorphism. In order to screen larger population samples for these polymorphisms, we developed a method

for each of the two polymorphisms consisting in a PCR amplification of the corresponding DNA fragment and subsequent restriction enzyme digestion (Figure 2). Neither the G1028G polymorphism nor the A595G polymorphism did significantly differ from the Hardy-Weinberg equilibrium ($P > 0.70$, $P > 0.10$, respectively, if a recessive effect was assumed).

In HeLa cells the G1028G polymorphism was detected in only one of the two alleles (heterozygous for the G1028G polymorphism (12)). The A595G mutation was absent in HeLa cells (homozygous for the A595A polymorphism (11)).

10.1.2. Population Genetics

A total of 3'078 individuals were enrolled. Two thousand six hundred individuals whose pretreatment total cholesterol levels had been measured were genotyped for the mutations and polymorphisms in four genes. A subgroup of 954 individuals were from randomly collected samples of cross-sectional surveys (SPREAD, IDA), 318 were unrelated individuals from the SIBSHIP study (one unaffected individual per family and all spouses, brothers and sisters in law who were genetically unrelated (REL)). A total of 871 individuals were enrolled from groups of patients with primary and secondary hyperlipoproteinemias. All 3'078 individuals of the groups of patients and the controls were screened for the presence of the mutation in the apo B-100 gene leading to an amino acid exchange at position 3'500 in order to identify patients with FDB in control samples and samples of patients with hyperlipoproteinemias. To identify patients with familial dysbetalipoproteinemia, all 3'078 individuals were also screened for the presence of the mutation in the apo E gene at amino acid position 158 (E2 allele) as well as for the presence for the mutation at position 112 (E4 allele). The presence of LDLR gene defects leads

as a rule to a significant, i.e. two- or threefold increase of total cholesterol concentrations, therefore only patients suffering from primary forms of hyperlipoproteinemias and clearly increased total cholesterol concentrations were tested for the presence of these mutations. Table 1 presents a summary of the different samples of patients and controls. Individuals identified in the control samples as having specific disorders leading to primary or secondary forms of hyperlipoproteinemia, respectively, were also included in the groups of patients having the respective disorder. Thus, the sum of subjects from all subgroups exceeds the total number of subjects (N=2'600). Table 1 stratifies the groups of patients and controls according to individuals with total cholesterol concentrations below the 90th percentile (normocholesterolemic, NC) and individuals with total cholesterol concentrations above the 90th percentile (hypercholesterolemic, HC).

The groups of patients and the controls listed in Table 1 were screened for the presence of the polymorphism described by using the methods indicated above (large scale, high throughput screening).

Three further genes were investigated: the apo E gene (amino acid polymorphisms C112R and R158C), the apo B-100 gene (mutation at amino acid position 3'500, R3'500Q). In the LDL receptor gene, mutations causing familial hypercholesterolemia were identified by using SSCP, subsequent amplification of the respective exons in which sequence variations were detected, subcloning, and sequencing.

A total of 3'078 subjects were investigated for the presence of the amino acid substitution in the apo B gene (R3'500Q), and for the presence of two amino acid polymorphisms in the apo E gene (C112R or E4 allele, R158C or E2 allele). All three mutations are known to modify the plasma cholesterol concentration.

In addition, 2'600 subjects were investigated for the novel DNA polymorphism in the SREBP-1 gene (G1028G) which was used as a marker. All 3'078 subjects were investigated for the novel DNA polymorphism in the SREBP-2 gene (A595G) causing an amino acid substitution.

In these subjects, plasma total cholesterol concentrations were measured. From the 3'078 subjects enrolled, 478 subjects took lipid-lowering drugs at study entry and pretreatment total cholesterol concentrations were not available. Therefore, these subjects were excluded from further analyses. Of the remaining 2'600 subjects pretreatment plasma total cholesterol concentrations adjusted for an age of 50 years as described were then included for further analysis. Table 2 summarizes the results of the prevalence of the two polymorphisms in the respective subgroups of patients and controls as well as the mean total cholesterol concentrations of the different subgroups in relation to the presence of the polymorphism.

Overall, a highly significant, cholesterol-lowering effect of the A595G mutation in the SREBP-2 gene was observed (Table 2, N=2'600; P=0.0005). This effect was even more pronounced, when subjects homozygous for the C112R mutation in the apo E gene (E4/E4) (N=107) were excluded from analysis (N=2'493; P<0.0001). If only genetically unrelated subjects were used in the analysis, thus excluding relatives from the SIBSHIP study, the probability for the difference being by chance decreased even more (N=2'446, P=0.0003). Figure 3 shows the analysis of the sample of unrelated subjects (N=2'446) which consisted of all subjects except the genetically related subjects from the SIBSHIP study, after stratification using different criteria. Figures 3A and B show the effect of the G1028G and the A595G polymorphisms in randomly selected subjects. Random samples (designated as such) with respect to hypercholesterolemia were the SPREAD and IDA studies as well as the samples of unrelated, unaffected

individuals (REL), and subjects collected because of a possible impairment of their memory functions (MCS). The other samples were selected because of the presence of hypercholesterolemia (non-random). Using analyses of variance (ANOVA, Scheffé's test), a significant effect was detected for the G1028G polymorphism, when the sample was stratified according to the selection groups (random/non-random) ($P=0.0164$). Likewise, the effect was detected in both groups with regard to the A595G mutation; ANOVA resulted in a probability for the difference being due to chance of $P<0.0001$. Figures 3C and D present the stratification with respect to the 90th percentile (NC, HC). In the G1028G polymorphism there was a significant effect when ANOVA was used ($P=0.0088$). In the A595G mutation analysis after inclusion of the additional factor resulted in a probability of $P<0.0001$ as well.

In addition, the known cholesterol-modifying effect of the apo E gene polymorphisms C112R ($\epsilon 4$) and R158C ($\epsilon 2$) could be demonstrated in our study population ($N=2'600$; $P<0.0001$).

Figures 3E and F demonstrate the gene-gene interactions between apo E and the SREBP-1 and -2 genes. No significant, cholesterol-modifying effect of the G1028G polymorphism in the SREBP-1 gene was detected when all 2'600 subjects were included in the analysis. After inclusion of the effects of the apo E genes into the analysis, in the G1028G polymorphism, the difference between the homozygous form of the polymorphism (22) and the two other alleles (11/12) was not significant (ANOVA, $P=0.0722$). However, when subjects homozygous or heterozygous for the apo E C112R ($\epsilon 4$) mutation were excluded ($N=761$), the effect of the absence of the wild-type allele on plasma total cholesterol levels was highly significant ($N=1'839$; $P<0.0001$). In the A595G polymorphism the difference between the homozygous form of the wild-type (11) and the two other alleles (12/22) was already highly significant ($P=0.0002$) after inclusion of the ef-

fects of the apo E gene in the analysis. When subjects homozygous or heterozygous for the apo E C112R (E4) mutation were excluded, the probability of the effect being due to chance decreased even further ($P < 0.0001$).

Further stratification of the samples according to the underlying disorders either as a cause of a primary or of a secondary hypercholesterolemia is summarized in Table 2. The results of the prevalence calculations of the two polymorphisms (G1028G, A595G) according to the different subgroups are shown in the first line. The results of the pretreatment total cholesterol mean values in the different subgroups, stratified for the presence or absence of the G1028G and A595G polymorphisms, are shown in the second line (Table 2). Regarding the subgroups with primary hyperlipidemias, the effect of the A595G mutation achieved statistical significance in the group of patients with FDL ($P = 0.0020$) and in the group of patients with primary hypercholesterolemia (PHC). In these patients mutations in the apo E, apo B, and LDLR genes had been excluded, although an autosomal dominantly or recessively inherited gene defect was suspected as a cause for hypercholesterolemia. In this latter sample, the prevalence of the wild-type (11) allele was significantly higher (9.38%) than in the sum of the other samples (6.69%) ($P = 0.0328$).

Regarding the samples of subjects with secondary hyperlipoproteinemias (which included both NC and HC subjects), in male subjects with diabetes mellitus and normal plasma triglyceride concentrations ($TG < 2.3 \text{ mmol/L}$) there was a significant difference between A595A (11) and A595G (12/22) positive individuals ($P = 0.0018$). In 11.6% of the subjects with secondary hyperlipoproteinemias plasma triglyceride concentrations were increased.

In the SREBP-1 gene, the prevalence of the wild-type allele in its homozygous state (11) was 40.35%, the prevalence of the G1028G polymorphism was in its heterozygous state (12) 45.62% and in its homozygous state

(22) 14.04% (N=2'600). In the SREBP-2 gene, the prevalence of the wild-type in its homozygous state (11) was 6.69%, the prevalence of the A595G mutation was in its heterozygous state (12) was 35.15% and in its homozygous state (22) 58.15% (N=2'600).

To elucidate the effect of the discovered DNA and amino acid polymorphisms on plasma total cholesterol levels, 3'078 individuals were tested molecularly. In 2'600 subjects, demographic as well as clinical data could be completed with age, gender, total cholesterol concentrations without treatment with lipid-lowering drugs at the time of cholesterol determination, genotypes with respect to the apo E amino acid polymorphisms (C112R or ϵ 4 allele, R158C or ϵ 2 allele), and the apo B100 mutation first discovered to be responsible for FDB (R3'500Q). The R158C amino acid polymorphism had, in its homozygous state, a cholesterol-modifying effect in the population studied ($P<0.0001$). In subjects positive for the R3'500Q mutation (FDB), total cholesterol concentrations were increased compared to the apo B defect negative individuals ($P<0.0001$). In subjects with confirmed LDL receptor mutations (FHM), mean total cholesterol concentrations were increased compared to controls ($P<0.0001$). Overall, the DNA polymorphism detected in the SREBP-1 gene (G1028G) did not significantly modify plasma total cholesterol concentrations in these subjects. However, in combination with the presence of the apo B R3'500Q mutation, the G1028G (22) polymorphism was significantly associated with an increase in plasma cholesterol concentrations ($P=0.0097$). Further stratification of the subjects involved in the study according to the underlying genetic disorders or according to the clinical diagnosis confirmed the effect of the novel SREBP-2 amino acid polymorphism on plasma total cholesterol concentrations in almost all groups, but none of the differences achieved statistical significance except in the group of patients with familial dysbetalipoproteinemia, FDL, and

in subjects having hypercholesterolemia due to unknown gene defects (PHC).

10.2 Association of the Novel A595G Mutation 5 with Senile Dementia of the Alzheimer Type

Another remarkable result of the present study was the significant prevalence of the wild type allele (A595A) compared to the amino acid substitution
10 (A595G) when a sample of clinically diagnosed Alzheimer's patients was compared with the prevalence in the general population (Table 2, 2.4% versus 7.0%, $P=0.0234$).

10.3. Association of the Novel G1028G polymorphism with the Absence of an increase of the Plasma Lipid Concentration Following Administration of Protease-inhibitors in HIV Patients

The results concerning differences in the
20 prevalence are also shown in Table 2 ($P=0.0339$). Figure 4 presents the percent change of the plasma cholesterol concentration before and after administration of protease-inhibitors, depending on the G1028G polymorphism.

25 11. Study comprising polymorphism in exon 6 of SREBP-2

11.1. Basics

30 Probands

A total of 1081 probands from the same groups as mentioned above (711 from the SPREAD study, 346 from the IDA study as well as 24 from a prospectively examined
35 collective of people who died in Basel (PATH study)) were enrolled in this study.

Material

In addition to the already described materials, restriction enzyme *Dde* I (New England Biolabs) was used.

Methods

Subjects enrolled in the study were additionally tested for a further mutation in the SREBP-2 gene (exon 6) leading to an amino acid substitution (R371K).

The SREBP-2 R371K mutation was essentially investigated as already described. In particular, the lipoprotein analysis, the DNA extraction method as well as the determination of the single stranded confirmation polymorphism by means of the non-radioactive method were performed as described above.

11.2 Sequencing of the exon 6 mutation of

20 SREBP-2

Sequencing was performed as described previously with the following modifications: exon 6 in the SREBP-2 gene was amplified by means of the oligonucleotides EcoRI.S2.6F (Seq. Id. No. 17): 5' CGGAATTCTGGTCTCACT GTGTTTTCACATC 3' and EcoR I.S2.6R (Seq. Id. No. 18): 5'-CG-GAATTCGCCAGGCTGACAAGCCTTTTCTCA-3'. Amplification reaction was performed in a total volume of 50 µl in 1x PCR buffer (Qiagen) using 0.4 U Taq polymerase (Qiagen) and final concentrations of 3.5 mM MgCl₂, 455 µM of each of the four dNTP (Qiagen) and 2.0 µM of each of the two oligonucleotides at the following temperatures: 94 °C, 45 sec.; 56°C, 30 sec; 72°C, 60 sec. (32 cycles). The amplified fragments were analyzed by means of subcloning and subsequent sequencing of the insert (as already described).

11.3 Methods for the identification of SREBP-2, exon 6 mutation by restriction enzyme digest

To detect the SREBP-2 mutation (exon 6, R371K) about 100 ng genomic DNA was amplified by the already described methods using oligonucleotides EcoR I.S2.6F and EcoR I.S2.6R. 20 µl were digested with 7 U Dde I in 1x NE buffer at a incubation temperature of 37°C for 5 hours. 4 µl 5x non denaturing loading buffer (El-chrom) were added to the reaction mixture. 7 µl of said mixture were loaded on Spreadex Wide-Mini S-100 gels (El-chrom), run at 55°C at 10V/cm for 25-45 minutes, de-stained with distilled water (40 minutes) and digitalized on a Gel Doc 1000 system.

11.4 Statistical methods

To compare the prevalences of sequence variations in the SREBP-1 and SREBP-2 genes the Chi-square test was used.

11.5 Evaluation of the results obtained according to the above indications

The 698 probands of the SPREAD study had an age median of 20.5 years (age range 18.8-43.7), the 370 probands of the IDA study had an age median of 74.5 years (age range 47.0-95.4 years). The comparison of the two groups of probands who were not selected but had a different age, showed statistically significant differences concerning the presence of SREBP-1 and SREBP-2 mutations.

The prevalence of the absence of SREBP-1c-G1028G polymorphism in homozygous form (i.e. genotype 11/12) in subjects of the SPREAD study was 622/711 (87.5 %) compared to 304/367 (82 %) in the subjects of the IDA/PATH study. This makes an absolute difference of -4.7

% (relative -5.4%, respectively) with a P-value of 0.038 (Chi square test).

The prevalence of the absence of the SREBP-2 A595G polymorphism in homozygous form (i.e. genotype 11/12) in probands of the SPREAD study was 305/711 (43 %) compared to 135/370 (36.5 %) in probands of the IDA/PATH study. This makes an absolute difference of -6.8 % (relative -15.1 %, respectively) with a P-value of 0.041.

The prevalence of the SREBP-2 R371K mutation in probands of the SPRED study was 19/698 (2.7 %) compared to 3/370 (0.8 %) in probands of the IDA/PATH study. This makes an absolute difference of -1.9 % (relative -70.4 %, respectively) with a P-value of 0.036.

11.6 Discussion

The differences in the prevalence data in the groups of younger or older probands, respectively, can only be explained by mortality differences since both random samples were taken from the same population.

Thus, in the IDA/PATH study population with an age median of 74.5 years numerous probands who are carriers of the SREBP-2 G1028G genotype 11/12 have already died: 316 carriers were expected in this group based on the data of the SPREAD study but only 304 probands were observed with this genotype (11/12), this means that 12 probands are missing in this group.

The same is true for carriers of the SREBP-2 A595G genotype 11/12: 159 carriers were expected in this group based on the data of the SPREAD study but only 135 probands with this genotype (11/12) were observed, 24 probands are therefore missing in this group.

The same is true for the rare carriers of the SREBP-2 R371K mutation: 10 carriers were expected based on the data of the SPREAD study but only 3 probands with this mutation were observed, 7 probands are therefore missing in this group.

One explanation for the significantly lower prevalence of certain sequence variations in SREBP-1 and SREBP-2 is the higher mortality of carriers of the genotypes SREBP-1.18c (11/12), SREBP-2.10 (11/12) and of the carriers of the SREBP-2 R371K mutation. This can for example be due to the already described association for the elevation of the plasma cholesterol level resulting in a coronary heart disease but as well due to the disproportionate occurrence of diseases such as e.g. senile dementia of the Alzheimer's type as already described, the two mentioned risk factors or combinations with further risk factors.

Table 1

Sample	Studies	Sample characterization	Age	Gender	All subjects		Normocholesterolemic subjects ¹⁾		Hypercholesterolemic subjects ¹⁾	
			Mean	m / (m+w)	A	TC Mean (±1SD)	A	TC Mean (±1SD)	A	TC Mean (±1SD)
All subjects										
TTL	SPREAD, SIBSHIP IDA, MCS, STARTER	All ages	45.55	0.66	2'600	6.84 ±2.52	1'980	5.80 ±1.32	620	10.14 ±2.58
Samples of subjects who were randomly selected										
RDM YNG	SPREAD	Random sample (young)	20.77	1.00	630	5.12 ±0.88	612	5.05 ±0.78	18	7.40 ±1.17
RDM ELD	IDA	Random sample (elderly)	75.98	0.67	324	6.46 ±1.49	316	6.39 ±1.45	8	8.93 ±1.01
Samples of subjects with disorders causing primary hyperlipoproteinemias										
FDL	SPREAD, SIBSHIP IDA, MCS, STARTER	Apolipoprotein E defect (R158C, homozygous)	46.17	0.76	46	9.90 ±4.10	15	5.27 ±1.43	31	12.15 ±2.89 →FDL
FDB	SPREAD, SIBSHIP IDA, MCS, STARTER	Apolipoprotein B defect (R3'500Q, heterozygous)	41.49	0.54	37	9,046 ±1.341	5	6.93 ±0.86	32	9.38 ±1.08 →FDB
FHM	SIBSHIP	LDLR defect (molecular-genet. detected)	34.87	0.51	74	10.93 ±2.43			74	10.93 ±2.43 →FH
PHC	SIBSHIP	Primary, isolated hypercholesterolemia ²⁾	40.58	0.55	341	9.90 ±2.62	-	-	341	9.90 ±2.62
PCH	SIBSHIP	Primary, combined hyperlipoproteinemia ²⁾	47.48	0.82	85	9.98 ±2.22	-	-	85	9.98 ±2.22 →FCH
REL	SIBSHIP	Relatives, not affected ³⁾	40.19	0.54	318	6.39 ±1.19	310	6.35 ±1.17	8	8.11 ±0.34

Samples of subjects with disorders causing secondary hyperlipoproteinemias⁴

DIA	STARTER,SIBSHIP IDA,MCS	Diabetes mellitus (Glucose/Plasma >7.8mmol/L)	50.96	0.59	229	6.48	±1.97	191	5.87	±1.21	38	9.55	±2.20	SHL
RIN	STARTER,SIBSHIP IDA,MCS	Renal insufficiency (Clearing cr < 50ml/min.)	76.63	0.44	131	7.17	±2.68	115	6.83	±2.58	16	9.65	±2.07	SHL
LIV	STARTER,SIBSHIP IDA,MCS	Alcohol consumption >60g/T and/or γ-GT >664U	53.32	0.85	151	8.22	±2.89	86	6.49	±1.25	65	10.52	±2.84	SHL
HTH	STARTER,SIBSHIP IDA,MCS	Hypothyroidism (TSH > 4.0mIU/L)	59.53	0.15	102	6.54	±1.97	86	5.92	±1.02	16	9.86	±2.49	SHL

Samples of subjects with potentially SREBP-1 and/or -2-related disorders

MEM.TTL	MCS	Adults (all age groups)	70.63	0.46	413	6.24	±1.67	387	6.09	±1.61	26	8.39	±0.93	
MEM.DAT		Dementia of Alzheimer Type (MMSE < 26)	73.50		41.2	165	6.16	±1.31	157	6.06	±1.25	8	8.17	±0.61
HIV.STB	STARTER	TC, not increasing with protease inhibitors ⁵	34.24		80.0	25	4.79	±1.31	24	4.70	±1.25	1	7.05	
HIV.INC		TC, increasing with Protease inhibitors ⁵	38.06		85.0	20	4.52	±0.91	20	4.52	±0.91			

¹ Normocholesterolemic; Plasma cholesterol < 90th percentile, age and sex-matched² Underlying molecular defects not known³ Only unrelated individuals (one non-affected person per family and all spouses, brothers in law and sisters in law genetically unrelated)⁴ Combined samples from individuals collected because of secondary hyperlipoproteinemias plus subjects collected from the other samples⁵ HIV positive individuals who experience no increase (STB) or an increase in total cholesterol plasma concentrations following administration of protease inhibitors (INC)

Table 2

Sample	SREBP-1 Polymorphism (G1028G)					SREBP-2 Polymorphism (A595G)				
	11	12	22	P $\Delta TC^{(5)}$	P $\Delta PR^{(3)}$	11	12	22	P $\Delta TC^{(6)}$	P $\Delta PR^{(4)}$
Prevalence ¹⁾ TC Mean ²⁾										
All subjects										
TTL										
PR	40.35 (1'049)	45.62 (1'186)	14.04 (365)			6.69 (174)	35.15 (914)	58.15 (1'512)		
TC	6.74 \pm 2.47	6.88 \pm 2.53	6.99 \pm 2.61	0.2309		7.47 \pm 3.48	6.83 \pm 2.57	6.77 \pm 2.34	0.0005	
Samples of subjects who were randomly selected										
RDM.YNG										
PR	41.75 (263)	45.71 (288)	12.54 (79)		0.3270	5.87 (37)	36.51 (230)	57.62 (363)		0.3445
TC	5.04 \pm 0.87	5.15 \pm 0.90	5.24 \pm 0.87	0.1735		5.15 \pm 0.85	5.06 \pm 0.91	5.15 \pm 0.87	0.7943	
RDM.ELD										
PR	41.36 (134)	40.74 (132)	17.90 (58)		0.0324	5.56 (18)	30.25 (98)	64.20 (208)		0.3815
TC	6.50 \pm 1.55	6.41 \pm 1.41	6.36 \pm 1.53	0.5796		6.77 \pm 1.51	6.55 \pm 1.66	6.39 \pm 1.40	0.3525	
Samples of subjects with disorders causing primary hyperlipoproteinemias										
FDL										
PR	32.26 (10)	41.94 (13)	25.81 (8)		0.0578	9.68 (3)	16.13 (5)	74.19 (23)		0.5034
TC	12.63 \pm 2.78	11.54 \pm 3.37	12.96 \pm 2.15	0.4351		16.89 \pm 3.45	10.62 \pm 1.76	12.01 \pm 2.47	0.0020	
FDB										
PR	33.33 (12)	38.89 (14)	16.67 (6)		0.4401	8.33 (3)	44.44 (16)	36.11 (13)		0.5412
TC	9.99 \pm 0.98	9.06 \pm 1.12	8.92 \pm 0.68	0.2393		8.63 \pm 0.22	9.21 \pm 1.09	9.77 \pm 1.01	0.1989	
FHM										
PR	33.78 (25)	48.65 (36)	17.57 (13)		0.3753	8.11 (6)	35.14 (26)	56.76 (42)		0.6210
TC	11.55 \pm 1.98	10.56 \pm 2.09	10.74 \pm 3.58	0.7579		11.15 \pm 2.34	11.06 \pm 2.13	10.81 \pm 2.59	0.8118	
PHC										
PR	38.12 (130)	48.09 (164)	13.78 (47)		0.8842	9.38 (32)	37.24 (127)	53.37 (182)		0.0328
TC	9.74 \pm 2.31	10.04 \pm 2.97	9.85 \pm 2.06	0.8737		10.89 \pm 4.82	9.90 \pm 2.20	9.72 \pm 2.31	0.0240	
PCH										
PR	41.18 (35)	43.53 (37)	15.29 (13)		0.7347	10.59 (9)	36.47 (31)	52.94 (45)		0.1439
TC	9.97 \pm 2.46	9.81 \pm 1.82	10.50 \pm 2.69	0.3650		9.71 \pm 2.23	10.35 \pm 2.98	9.78 \pm 1.53	0.7019	
REL										
PR	39.62 (126)	46.86 (149)	13.52 (43)		0.7772	6.60 (21)	33.33 (106)	60.06 (191)		0.9462
TC	6.38 \pm 1.16	6.44 \pm 1.09	6.27 \pm 1.55	0.4679		6.43 \pm 1.10	6.33 \pm 1.26	6.42 \pm 1.16	0.8984	

SREBP-1 Polymorphism (G1028C)

	11		12		22		P		P $\Delta PR^{(3)}$	P $\Delta TC^{(5)}$	11	12	22	P $\Delta TC^{(4)}$	P $\Delta PR^{(4)}$
	Prevalence ⁽¹⁾ TC mean ⁽²⁾														
Samples of subjects with disorders causing secondary hyperlipoproteinemias ⁴															
DIA	PR	39.30 (90)	43.67 (100)	17.03 (39)					0.1723		6.55 (15)	38.86 (89)	54.59 (125)		0.9282
	TC	6.47 \pm 1.78	6.44 \pm 1.88	6.62 \pm 2.57	0.6233		6.48 \pm 1.69	6.47 \pm 1.92	6.49 \pm 2.05	0.9985					
RIN	PR	40.46 (53)	45.80 (60)	13.74 (18)					0.9197		6.11 (8)	40.46 (53)	53.44 (70)		0.7832
	TC	7.27 \pm 3.37	7.15 \pm 2.01	6.96 \pm 2.49	0.7193		7.44 \pm 2.04	7.14 \pm 3.42	7.16 \pm 2.07	0.7692					
LIV	PR	38.51 (57)	47.30 (70)	14.19 (21)					0.9567		8.11 (12)	32.43 (48)	61.49 (91)		0.5249
	TC	8.14 \pm 2.55	8.53 \pm 3.31	7.92 \pm 2.11	0.6011		9.81 \pm 4.78	8.02 \pm 3.06	8.25 \pm 2.43	0.0696					
HTH	PR	37.63 (35)	46.24 (43)	16.13 (15)					0.5545		6.45 (6)	24.73 (23)	68.82 (64)		0.9246
	TC	6.17 \pm 1.80	6.55 \pm 1.87	6.00 \pm 1.29	0.2678		7.46 \pm 1.56	7.09 \pm 2.78	6.00 \pm 1.11	0.1174					

Samples of subjects with potentially SREBP-1 and/or -2-related disorders

TTL-DAT	PR 40.16 (978)	45.59 (1110)	14.25 (347)			6.98 (170)	34.99 (852)	58.03 (1413)		
	TC 6.78 \pm 2.53	6.82 \pm 2.58	7.05 \pm 2.63	0.2225		7.48 \pm 3.52	6.88 \pm 2.63	6.81 \pm 2.39	0.0018	
DAT	PR 43.03 (71)	46.06 (76)	10.91 (18)		0.2318	2.42 (4)	37.58 (62)	60.00 (99)		0.0234
	TC 6.14 \pm 1.22	6.24 \pm 1.28	5.92 \pm 1.78	0.4050		7.44 \pm 1.19	6.14 \pm 1.34	6.12 \pm 1.28	0.0487	
HIV-STB	PR 52.00 (13)	28.00 (7)	20.00 (5)			16.00 (4)	36.00 (9)	48.00 (12)		
	TC 4.85 \pm 1.53	4.27 \pm 0.59	5.37 \pm 1.37	0.2772		3.99 \pm 0.62	4.77 \pm 1.47	5.08 \pm 1.32	0.1855	
HIV-INC	PR 40.00 (8)	60.00 (12)	0.00 (0)		0.0339	5.00 (1)	45.00 (9)	50.00 (10)		0.2433
	TC 4.26 \pm 1.03	4.70 \pm 0.82	-	-		2.13	4.80 \pm 0.26	4.51 \pm 0.98	0.0036	

¹⁾ Prevalence (\pm PR) in percent (number of subjects)

²⁾ Mean of plasma total cholesterol concentrations (\pm TC) in mmol/L (\pm SD)

³⁾ ΔPR = PR 11/12 vs. PR 22; significance level (P) of the difference between prevalence of sample (PR, Sample) vs. prevalence of all subjects (PR, TTL) minus prevalence of respective sample (PR, Sample); (P of PR, Sample vs. (PR, TTL - PR, Sample))

⁴⁾ ΔPR = PR 11 vs. PR 12/22; significance level (P) of the difference between prevalence sample (PR, Sample) vs. prevalence of subjects (PR, TTL) minus prevalence of respective sample (PR, Sample); (P of PR, Sample vs. (PR, TTL - PR, Sample))

⁵⁾ ΔTC = TC 11/12 vs. TC 22 / ⁶⁾ ΔTC = TC 11 vs. TC 12/22

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Claims

1. A method for the detection of an increased or decreased disease risk and/or mortality risk and/or an increased or decreased sensitivity to a method of therapy or their side effects, characterized in that after taking a blood or a tissue sample, respectively, said blood or tissue, respectively, is examined for the presence of a polymorphism in at least one sterol regulator element binding protein (SREBP) wherein the presence of a polymorphism is determined at amino acid and/or nucleic acid level.

2. The method of claim 1, characterized in that said SREBP is selected from the group comprising SREBP-1 and SREBP-2.

3. The method according to claim 1 or 2, characterized in that said polymorphism leads an increased or decreased activation of genes of the lipid metabolism, in particular of the cholesterol metabolism.

4. The method of claim 3, characterized in that said polymorphism leads to an increased or decreased plasma concentration of at least one lipid, in particular cholesterol.

5. The method of any one of claims 1 to 4, characterized in that the presence of a polymorphism is determined at nucleic acid level.

6. The method of claim 5, characterized in that said polymorphism shows a recognition site for a cleavage site lying within said polymorphism and that the examination is done using said recognition sequence.

7. The method of claim 6, characterized in that said recognition sequence is a recognition sequence for *Xmn* I or *Msp* I i.e. GAANNNTTC or CCGG, wherein N can be any nucleotide.

8. The method of claim 7, characterized in that the examination is done using a SREBP sequence or a SREBP partial sequence comprising a nucleic acid sequence selected from the group of the following sequences, optionally together with further nucleic acids of the natural vicinity of the corresponding sequence:

SREBP-1, exon 18c (Seq. Id. No. 3):

GCACCTAGGGAAAGGCTTC

SREBP-2, exon 10 (Seq. Id. No. 7):

CTGCTGCCGGCAACCTACA

9. The method of claim 6, characterized in that the examination is done using a SREBP sequence or a SREBP partial sequence comprising the following nucleic acid sequence, optionally together with further nucleic acids of the natural vicinity of said sequence:

SREBP-2, exon 6: CTGAAGAAG

10. The method of any one of claims 1 to 4, characterized in that the detection of the presence of a polymorphism is done at amino acid level.

11. Method of any one of claims 1 to 9, characterized in that after taking blood or a tissue sample, respectively, and DNA extraction at least a fragment of a SREBP exon comprising a polymorphism is amplified using two oligonucleotide sequences wherein said polymorphism is characteristic for an increased or decreased activation of genes of the lipid metabolism, in particular cholesterol metabolism, and that the product of said amplification is subjected to a digestion with a suitable restriction enzyme or a denaturation and that the digestion products or denaturation products, respectively, are separated electrophoretically.

12. The method of claim 10 or 11, characterized in that said polymorphism is characteristic for an increased or decreased risk for hypercholesterolemia in humans.

13. The method of claim 11 or 12, characterized in that at least one of said oligonucleotide sequences is located in the intron region which is adjacent to the exon where said polymorphism exists.

14. The method of any one of claims 11 to 13, characterized in that said oligonucleotide sequences are selected from the following pairs or from sequences which hybridize to said pairs under stringent conditions:

S1.18cF (Seq. Id. No. 9):

5'-TTATTTATAATCTGGGTTTGTGTC-3' and

S1.18cR (Seq. Id. No. 10):

5'-GGGAAGAGCTAAGTTAAAAGTTGTG-3' or

EcoR I.S1.18cF (Seq. Id. No. 11):

5'-CGGAATTCTGAAATTATTTATAATCTGGGTTTGTGTC-3' and

EcoR I.S1.18cR (Seq. Id. No. 12):

5'-CGGAATTCATCGGGGAAGAGCTAAGTTAAAAGTTGTG-3' or

S2.10P.F (Seq. Id. No. 13):

5'-GCCAGTGACCATTAACACCTTTTGA-3' and

S2.10P.R. (Seq. Id. No. 14):

5'-TCGTCTTCAAAGCCTGCCTCAGTGGCTGGC-3' or

EcoRI S2.10F (Seq. Id. No. 15):

5'-CGGAATTCGCCAGTGACCATTAACACCTTTTGA-3' and

EcoRI S2.10R (Seq. Id. No. 16):

5'-CGGAATTCTGCAGCAAGCCAGTCATCAGCAGCT-3'

EcoRI S2.6F (Seq. Id. No. 17):

5'-CGGAATTCTGGTCTCACTGTGTTTCACTCATC-3'

EcoRI S2.6R (Seq. Id. No. 18):

5'-CGGAATTCGCCAGGGCTGACAAGCCTTTTCTCA-3'.

15. The method of any one of claims 1 to 14, characterized in that said polymorphism has been detected by amplification and analysis of a SREBP sequence of interest, comparison of the exon regions of said sequence of interest to the exon regions of the type of sequence of the corre-

sponding SREBP which is most often found in a population and examination of the sequences with found differences for dysfunction.

16. The method of claim 15, characterized in that the differences lead to a different amino acid and/or in particular to an recognition site for a restriction enzyme.

17. Use of a method of any one of claims 1 to 16 for the detection of an increased or reduced risk for hypercholesterolemia and/or Alzheimer's disease.

18. Use of a method of any one of claims 11 to 16 for the detection of an increased or decreased risk for the occurrence of side effects associated with HIV therapy, in particular the therapy with protease inhibitors.

19. Use of a method of any one of claims 1 to 16 for an increased or decreased mortality risk.

20. DNA and/or RNA chip characterized in that said chip comprises at least one polymorphism in a SREBP, in particular in SREBP-1 and/or SREBP-2.

21. DNA and/or RNA chip of claim 20 characterized in that said polymorphism is a polymorphism in SREBP-1 and/or SREBP-2 as defined in claims 3, 4, 6, 7, 8 and 9.

22. DNA and/or RNA chip of claim 20 or 21 comprising said polymorphism in presence of other polymorphisms which are diagnostic for the risk assessment of hypercholesterolemia and/or Alzheimer's disease.

23. Use of a polymorphism as defined in one of claims 3, 4, 6, 7, 8 and 9 or of a chip of one of claims 20 to 22 as marker for the determination of an increased or reduced risk for the outbreak of a disease.

24. Use of claim 23, characterized in that said disease is selected from hypercholesterolemia and Alzheimer's disease.

25. Use of a polymorphism as defined in one of claims 3, 4, 6, 7, 8 and 9 or a chip of one of claims 20 to 22 for the determination of an increased or reduced risk for the occurrence of side effects associated with HIV therapy, in particular the therapy with protease inhibitors.

26. Use of a polymorphism as defined in one of claims 3, 4, 6, 7, 8 and 9 or a chip of one of claims 20 to 22 for the determination of a reduced mortality risk.

27. Use of a polymorphism as defined in one of claims 3, 4, 6, 7, 8 and 9 or a chip of one of claims 20 to 22 for the evaluation of a method of treatment for a disease selected from the group comprising hypercholesterolemia, Alzheimer's disease and HIV or for drug screening.

28. Polymorphism characteristic for an increased or reduced risk for hypercholesterolemia in humans characterized in that said polymorphism occurs in a sterol regulator element binding protein (SREBP).

29. Polymorphism of claim 28, characterized in that said polymorphism occurs in the SREBP-1 or SREBP-2.

30. Polymorphism of claim 29, characterized in that said polymorphism shows a recognition site for XmnI or MspI i.e. GAANNNTTC or CCGG wherein N can be any nucleotide.

31. Polymorphism of claim 30, characterized in that said polymorphism comprises the following sequences:

SREBP-1, exon 18c (Seq. Id. No. 3):

GCACCTAGGGAAAGGCTTC

SREBP-2, exon 10 (Seq. Id. No. 7):

CTGCTGCCGGCAACCTACA

Abstract

The invention relates to DNA polymorphisms in sterol regulator element binding proteins (SREBP) that are characteristic of a higher risk of genetic diseases in humans such as hypercholesterolemia. The corresponding polymorphisms, especially the polymorphisms on SREBP-1 and SREBP-2 are frequently observed in Alzheimer patients (SREBP-2). They are also characterized by a specific behavior in the therapy of HIV patients with protease inhibitors and appear to have an influence on the mortality.

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicants : André R. Miserez
Serial No. : Not Yet Known
Filing Date : Herewith
For : DNA Polymorphisms in Sterol Regulator Element Binding Proteins
Priority Date
Claimed : July 9, 1999
Group A.U. : Not Yet Known
Examiner : Not Yet Known

1185 Avenue of the Americas
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January 8, 2002

Assistant Commissioner for Patents
Washington, D.C. 20231
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PRELIMINARY AMENDMENT

SIR:

Before examining the subject application, please amend it as follows:

IN THE CLAIMS

Please amend claims 3, 5, 10-15, 17-19, 21-23, and 25-27 as follows:

--3. (Amended) The method according to claim 1, characterized in that said polymorphism leads to an increased or decreased activation of genes of the lipid metabolism, in particular of the cholesterol metabolism.--

--5. (Amended) The method of claim 1, characterized in that the presence of a polymorphism is determined at nucleic acid level.--

--10. (Amended) The method of claim 1, characterized in that the detection of the presence of a polymorphism is done at amino acid level.--

--11. (Amended) Method of claim 1, characterized in that after taking blood or a tissue sample, respectively, and DNA extraction at least a fragment of a SREBP exon comprising a polymorphism is amplified using two oligonucleotide sequences wherein said polymorphism is characteristic for an increased or decreased activation of genes of the lipid metabolism, in particular cholesterol metabolism, and that the product of said amplification is subjected to a digestion with a suitable restriction enzyme or a denaturation and that the digestion products or denaturation products, respectively, are separated electrophoretically.--

--12. (Amended) The method of claim 10, characterized in that said polymorphism is characteristic for an increased or decreased risk for hypercholesterolemia in humans.--

--13. (Amended) The method of claim 11, characterized in that at least one of said oligonucleotide sequences is located in the intron region which is adjacent to the exon where said polymorphism exists.--

--14. (Amended) The method of claim 11, characterized in that said oligonucleotide sequences are selected from the following pairs or from sequences which hybridize to said

pairs under stringent conditions:

S1.18cF (Seq. Id. No. 9):

5'-TTATTTATAATCTGGGTTTTGTGTC-3' and

S1.18cR (Seq. Id. No. 10):

5'-GGGAAGAGCTAAGTTAAAAGTTGTG-3' or

EcoR I.S1.18cF (Seq. Id. No. 11):

5'-CGGAATTCTGAAATTATTATAATCTGGGTTTTGTGTC-3' and

EcoR I.S1.18cR (Seq. Id. No. 12):

5'-CGGAATTCATCGGGGAAGAGCTAAGTTAAAAGTTGTG-3' or

S2.10P.F (Seq. Id. No. 13):

5'-GCCAGTGACCATTAAACACCTTTTGA-3' and

S2.10P.R. (Seq. Id. No. 14):

5'-TCGTCTTCAAAGCCTGCCTCAGTGGCTGGC-3' or

EcoRI S2.10F (Seq. Id. No. 15):

5'-CGGAATTCGCCAGTGACCATTAAACACCTTTTGA-3' and

EcoRI S2.10R (Seq. Id. No. 16):

5'-CGGAATTCTGCAGCAAGCCAGTCATCAGCAGCT-3'

EcoRI S2.6F (Seq. Id. No. 17):

5'-CGGAATTCTGGTCTCACTGTGTTTCACTCATC-3'

EcoRI S2.6R (Seq. Id. No. 18):

5'-CGGAATTCGCCAGGGCTGACAAGCCTTTTCTCA-3'--

--15. (Amended) The method of claim 1, characterized in that said polymorphism has

been detected by amplification and analysis of a SREBP sequence of interest, comparison of the exon regions of said sequence of interest to the exon regions of the type of sequence of the corresponding SREBP which is most often found in a population and examination of the sequences with found differences for dysfunction.--

--17. (Amended) Use of a method of claim 1 for the detection of an increased or reduced risk for hypercholesterolemia and/or Alzheimer's disease.--

--18. (Amended) Use of a method of claim 11 for the detection of an increased or decreased risk for the occurrence of side effects associated with HIV therapy, in particular the therapy with protease inhibitors.--

--19. (Amended) Use of a method of claim 1 for an increased or decreased mortality risk.--

--21. (Amended) DNA and/or RNA chip that comprises at least one polymorphism in a SREBP, in particular in SREBP-1 and/or SREBP-2 characterized in that said polymorphism is a polymorphism in SREBP-1 and/or SREBP-2 as defined in claim 3.

--22. (Amended) DNA and/or RNA chip of claim 20 comprising said polymorphism in presence of other polymorphisms which are diagnostic for the risk assessment of hypercholesterolemia and/or Alzheimer's disease.--

--23. (Amended) Use of a polymorphism that leads to an increased or decreased

activation of genes of the lipid metabolism, in particular of the cholesterol metabolism, or of a chip of claim 20 as marker for the determination of an increased or reduced risk for the outbreak of a disease.--

--25. (Amended) Use of a polymorphism that leads to an increased or decreased activation of genes of the lipid metabolism, in particular of the cholesterol metabolism, or a chip of claim 20 for the determination of an increased or reduced risk for the occurrence of side effects associated with HIV therapy, in particular the therapy with protease inhibitors.--

--26. (Amended) Use of a polymorphism that leads to an increased or decreased activation of genes of the lipid metabolism, in particular of the cholesterol metabolism, or a chip of claim 20 for the determination of a reduced mortality risk.--

--27. (Amended) Use of a polymorphism that leads to an increased or decreased activation of genes of the lipid metabolism, in particular of the cholesterol metabolism, or a chip of claim 20 for the evaluation of a method of treatment for a disease selected from the group consisting of hypercholesterolemia, Alzheimer's disease and HIV or for drug screening.--

REMARKS

Claims 3, 5, 10-15, 17-19, 21-23, and 25-27 have been amended to reduce the filing fee. Favorable action is respectfully requested.

Respectfully submitted,
COOPER & DUNHAM LLP



Donald S. Dowden
Reg. No. 20,701

VERSION WITH MARKINGS TO SHOW CHANGES MADE

IN THE CLAIMS

Claims 3, 5, 10-15, 17-19, 21-23, and 25-27 have been amended as follows:

--3. (Amended) The method according to claim 1 [or 2], characterized in that said polymorphism leads to an increased or decreased activation of genes of the lipid metabolism, in particular of the cholesterol metabolism.--

--5. (Amended) The method of [any one of] claim[s] 1 [to 4], characterized in that the presence of a polymorphism is determined at nucleic acid level.--

--10. (Amended) The method of [any one of] claim[s] 1 [to 4], characterized in that the detection of the presence of a polymorphism is done at amino acid level.--

--11. (Amended) Method of [any one of] claim[s] 1 [to 9], characterized in that after taking blood or a tissue sample, respectively, and DNA extraction at least a fragment of a SREBP exon comprising a polymorphism is amplified using two oligonucleotide sequences wherein said polymorphism is characteristic for an increased or decreased activation of genes of the lipid metabolism, in particular cholesterol metabolism, and that the product of said amplification is subjected to a digestion with a suitable restriction enzyme or a denaturation and that the digestion products or denaturation products, respectively, are separated electrophoretically.--

--12. (Amended) The method of claim 10 [or 11], characterized in that said polymorphism is characteristic for an increased or decreased risk for hypercholesterolemia in humans.--

--13. (Amended) The method of claim 11 [or 12], characterized in that at least one of said oligonucleotide sequences is located in the intron region which is adjacent to the exon

where said polymorphism exists.--

--14. (Amended) The method of [any one of] claim[s] 11 [to 13], characterized in that said oligonucleotide sequences are selected from the following pairs or from sequences which hybridize to said pairs under stringent conditions:

S1.18cF (Seq. Id. No. 9):

5'-TTATTTATAATCTGGGTTTTGTGTC-3' and

S1.18cR (Seq. Id. No. 10):

5'-GGGAAGAGCTAAGTTAAAAGTTGTG-3' or

EcoR I.S1.18cF (Seq. Id. No. 11):

5'-CGGAATTCTGAAATTATTATAATCTGGGTTTTGTGTC-3' and

EcoR I.S1.18cR (Seq. Id. No. 12):

5'-CGGAATTCATCGGGGAAGAGCTAAGTTAAAAGTTGTG-3' or

S2.10P.F (Seq. Id. No. 13):

5'-GCCAGTGACCATTAAACACCTTTTGA-3' and

S2.10P.R. (Seq. Id. No. 14):

5'-TCGTCTTCAAAGCCTGCCTCAGTGGCTGGC-3' or

EcoRI S2.10F (Seq. Id. No. 15):

5'-CGGAATTCGCCAGTGACCATTAAACACCTTTTGA-3' and

EcoRI S2.10R (Seq. Id. No. 16):

5'-CGGAATTCTGCAGCAAGCCAGTCATCAGCAGCT-3'

EcoRI S2.6F (Seq. Id. No. 17):

5'-CGGAATTCTGGTCTCACTGTGTTTCACTCATC-3'

EcoRI S2.6R (Seq. Id. No. 18):

5'-CGGAATTCGCCAGGGCTGACAAGCCTTTTCTCA-3'--

--15. (Amended) The method of [any one of] claim[s] 1 [to 14], characterized in that said polymorphism has been detected by amplification and analysis of a SREBP sequence of interest, comparison of the exon regions of said sequence of interest to the exon regions of the type of sequence of the corresponding SREBP which is most often found in a population and examination of the sequences with found differences for dysfunction.--

--17. (Amended) Use of a method of [any one of] claim[s] 1 [to 16] for the detection of an increased or reduced risk for hypercholesterolemia and/or Alzheimer's disease.--

--18. (Amended) Use of a method of [any one of] claim[s] 11 [to 16] for the detection of an increased or decreased risk for the occurrence of side effects associated with HIV therapy, in particular the therapy with protease inhibitors.--

--19. (Amended) Use of a method of [any one of] claim[s] 1 [to 16] for an increased or decreased mortality risk.--

--21. (Amended) DNA and/or RNA chip [of claim 20] that comprises at least one polymorphism in a SREBP, in particular in SREBP-1 and/or SREBP-2 characterized in that said polymorphism is a polymorphism in SREBP-1 and/or SREBP-2 as defined in claim[s] 3[, 4 6, 7, 8 and 9].

--22. (Amended) DNA and/or RNA chip of claim 20 [or 21] comprising said polymorphism in presence of other polymorphisms which are diagnostic for the risk assessment of hypercholesterolemia and/or Alzheimer's disease.--

--23. (Amended) Use of a polymorphism [as defined in one of claims 3, 4, 6, 7, 8 and 9] that leads to an increased or decreased activation of genes of the lipid metabolism, in particular of the cholesterol metabolism, or of a chip of [one of] claim[s] 20 [to 22] as marker for the determination of an increased or reduced risk for the outbreak of a disease.--

--25. (Amended) Use of a polymorphism [as defined in one of claims 3, 4, 6, 7, 8 and 9] that leads to an increased or decreased activation of genes of the lipid metabolism, in particular of the cholesterol metabolism, or a chip of [one of] claim[s] 20 [to 22] for the determination of an increased or reduced risk for the occurrence of side effects associated with HIV therapy, in particular the therapy with protease inhibitors.--

--26. (Amended) Use of a polymorphism [as defined in one of claims 3, 4, 6, 7, 8 and 9] that leads to an increased or decreased activation of genes of the lipid metabolism, in particular of the cholesterol metabolism, or a chip of [one of] claim[s] 20 [to 22] for the determination of a reduced mortality risk.--

--27. (Amended) Use of a polymorphism [as defined in one of claims 3, 4, 6, 7, 8 and 9] that leads to an increased or decreased activation of genes of the lipid metabolism, in particular of the cholesterol metabolism, or a chip of [one of] claim[s] 20 [to 22] for the evaluation of a method of treatment for a disease selected from the group [comprising] consisting of hypercholesterolemia, Alzheimer's disease and HIV or for drug screening.--

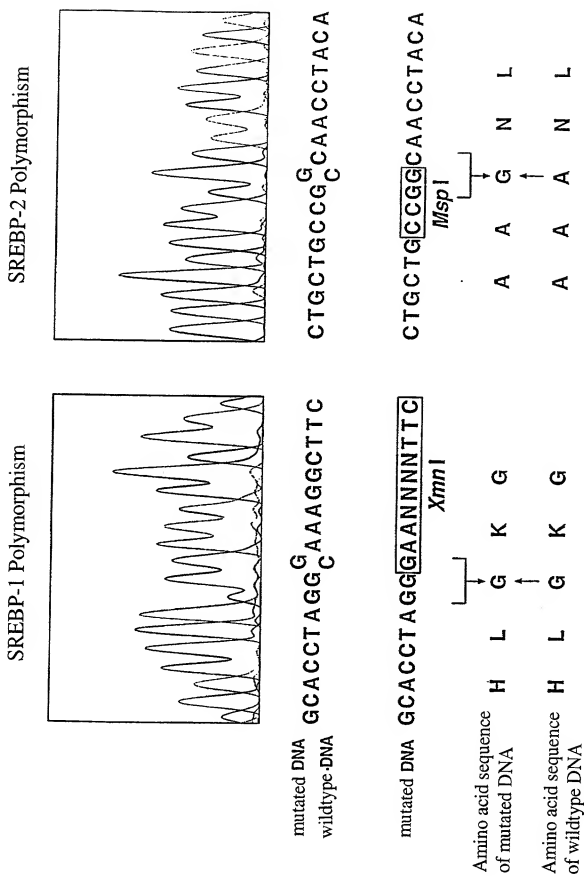
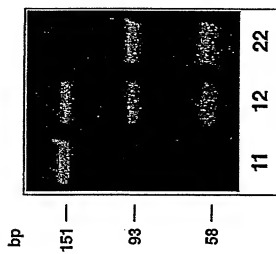


Figure 1A

Figure 1B

SREBP-1 Polymorphism



Intron 19a Exon 18c

S1.18c.F S1.18c.R

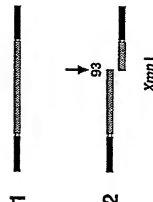
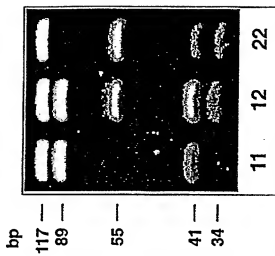


Figure 2A

SREBP-2 Polymorphism



Intron 9 Exon 10

S2.10P.F S2.10P.R

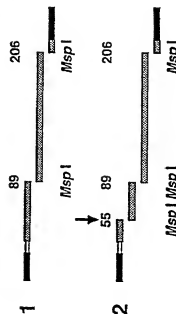
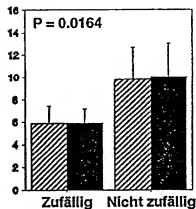


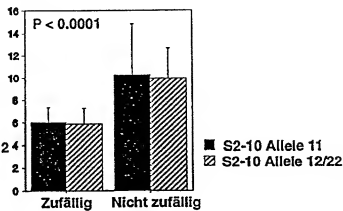
Figure 2B

SREBP-1 Polymorphism
(mmol/L)

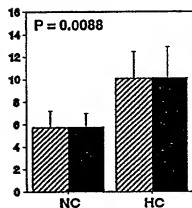
A

SREBP-2 Polymorphism
(mmol/L)

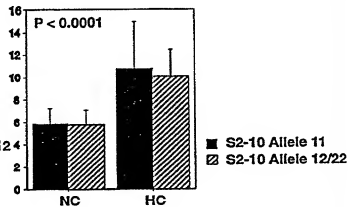
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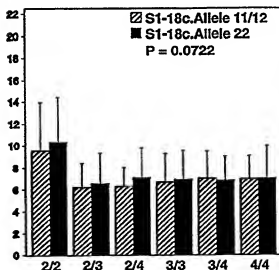
C



D



E



F

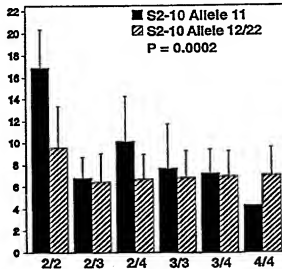


Figure 3

Change
of total cholesterol concentration
after treatment with protease inhibitors
(in percent)

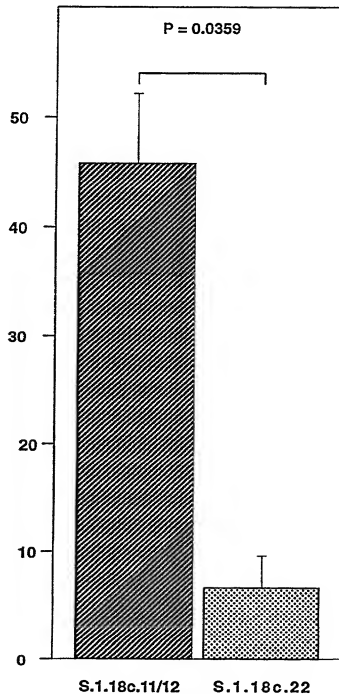


Figure 4

10/030504

531 Rec'd PCI/75

08 JAN 2002

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<110> Miserez, André R

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DECLARATION AND POWER OF ATTORNEY

10/030504

As a below-named inventor, I hereby declare that:

My residence, post office address, and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

the specification of which
(check one)

_____ is attached hereto
XX was filed on _____ as
Application Serial No. _____
and was amended on _____
(if applicable)

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose to the U.S. Patent and Trademark Office all information known to me to be material to the patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, Section 119(a)-(d) or Section 365(b) of any foreign application(s) for patent or inventor's certificate, or Section 365(a) of any PCT International Application which designated at least one country other than the United States, listed below. I have also identified below any foreign application for patent or inventor's certificate, or PCT International Application having a filing date before that of the earliest application from which priority is claimed:

Prior Foreign Application(s)

Priority Claimed

Number	Country	Filing Date	Yes	No
1277/99	Switzerland	9 July 1999	X	
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____

I hereby claim the benefit under Title 35, United States Code, Section 119(e) of any United States provisional application(s) listed below:

Provisional Application Serial No.	Filing Date	Status
_____	_____	_____
_____	_____	_____
_____	_____	_____

I hereby claim the benefit under Title 35, United States Code, Section 120 of any United States Application(s), or Section 365(c) of any PCT International Application(s) designating the United States listed below. Insofar as this application discloses and claims subject matter in addition to that disclosed in any such prior Application in the manner provided by the first paragraph of Title 35, United States Code, Section 112, I acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56, which became available between the filing date(s) of such prior application(s) and the national or PCT international filing date of this application:

Application Serial No.	Filing Date	Status
_____	_____	_____
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_____	_____	_____

And I hereby appoint:

Donald S. Dowden, Reg. No. 20,701; Ivan S. Kavrukov Reg. No. 25,161; Christopher C. Dunham Reg. No. 22,031; Jay H. Maioli, Reg. No. 27,213; William E. Pelton, Reg. No. 25,702; Robert D. Katz, Reg. No. 30,141; and each of them, all c/o Cooper & Dunham LLP of 1185 Avenue of the Americas, New York, NY 10036 (Tel: 212-278-0400), my attorneys, each with full power of substitution and revocation, to prosecute this application, to make alterations and amendments therein, to receive the patent, to transact all business in the Patent and Trademark Office connected therewith and to file any International Applications which are based thereon under the provisions of the Patent Cooperation Treaty.

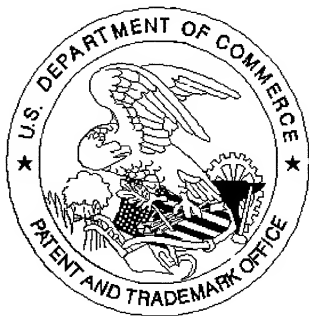
Please address all communications, and direct all telephone calls, regarding this application to

Donald S. Dowden Reg. No. 20,701
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 Tel. (212) 278-0400

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Full name of sole or first joint inventor André R. Miserez
 Inventor's signature [Signature]
 Citizenship Swiss Date of Signature December 28, 2001
 Residence St. Jakobstrasse 70, CH-4147 Aesch, Switzerland
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